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NOTICE

For the convenience of the readers, enabling them to preserve and to bind separately the literary and scientific material, the *Journal and Proceedings of the Asiatic Society of Bengal* will from 1935 be issued in three separate parts, each with its own title, page numbering, and index.

The titles of the three parts will be:—

Journal of the Asiatic Society of Bengal. Letters.
Journal of the Asiatic Society of Bengal. Science.
Year-Book of the Asiatic Society of Bengal.

The *Year-Book* will contain the matter hitherto published in the *Proceedings* of the Society.

The following abbreviations are recommended for use in references: JASBL.; JASBSc.; and YBASB.

The volume and year numbers will be the same for the three parts of the Journal.

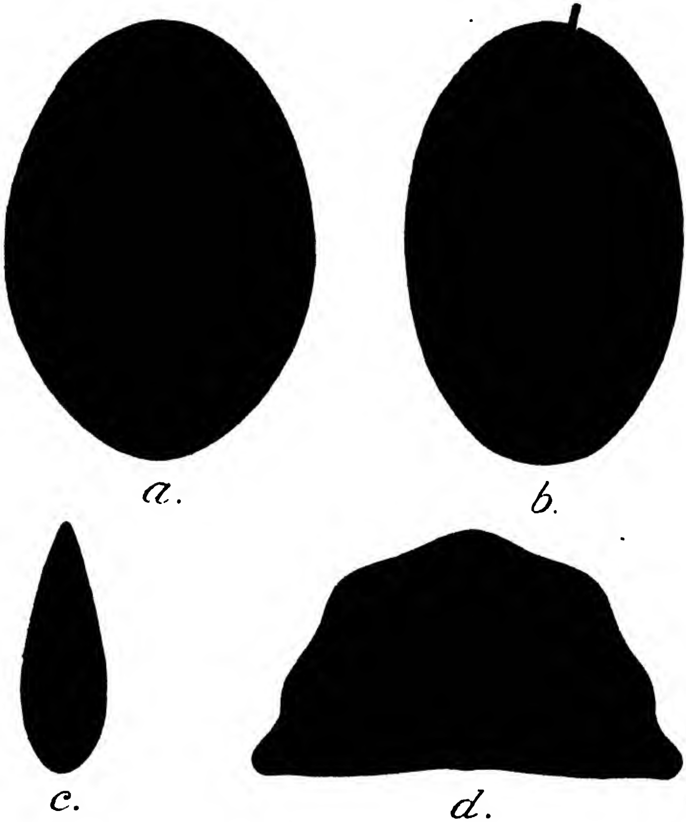
The new form of issue will constitute a third series of the *Journal* of which the history is as follows:—

First Series (1)	Journal,	Vols.	-73,	1832-1904
(2)	Proceedings,	Vols.	-40.	1865-1904.
New (i.e. Second) Series	Journal and Proceedings,	Vols.	-30,	1905-1934
Third Series (1)	Journal. Letters.	Vol.	- ,	1935- .
(2)	Journal. Science,	Vol.	,	1935
(3)	Year-Book,	Vol	,	1935

CALCUTTA,
1, PARK STREET,
January, 1935.

JOHAN VAN MANEN,
General Secretary,
Asiatic Society of Bengal.

freshwater animals are divided into two main categories, (i) animals of flowing water and (ii) animals of standing water. Each of these groups can be again divided into two formations according to habitat, making four in all:—(1) animals of rapidly



Text-fig. 2.—Transverse sections through the deepest part (about commencement of dorsal) of the four types of fishes from different habitats.

a. Barbus tor (Ham. Buch.), a river fish. $\times\frac{2}{7}$; *b. Catla catla* (Ham. Buch.), a tank fish. $\times\frac{2}{7}$; *c. Barbus ticto* (Ham. Buch.), a pond or pool fish. $\times 1\frac{3}{7}$; *d. Balitora brucei* Gray, a torrential fish. $\times 3\frac{2}{21}$.

Barbus tor : Length 46·5 inches; greatest girth 23·5 inches. *ca.* 50%.
Catla catla : Length 23·0 inches; greatest girth 21·0 inches. *ca.* 91%.
Barbus ticto : Length 2·5 inches; greatest girth 2·0 inches. *ca.* 80%.
Balitora brucei : Length 4·2 inches; greatest girth 1·7 inches. *ca.* 43%.

flowing streams, (2) animals of slowly flowing streams, (3) animals of lakes and other larger pieces of water, and (4) animals of pools, ponds, springs and other small, confined stretches of water. All these habitats can be classified further into 'associations'

and 'strata', but, so far as the fish are concerned, the smaller divisions are not of much significance.

Form :—It is well known that the great diversity of form found among fishes is definitely correlated with their equally diversified modes of locomotion. For instance, in fishes adapted for rapid locomotion, the body forms a simple wedge for cleaving the water. In bottom fishes the head and body are greatly depressed for crawling, whereas in fishes that move comparatively slowly through water or just remain suspended in it, the body is laterally compressed and the vertical axis is greatly lengthened. In burrowing fishes, or fishes that normally live in crevices and holes, the body is snake-like. 'The old ichthyologists, even down to Linnaeus, depended in great measure on them [body forms] for classification; but although often the same form of body obtains in the same group of fishes, similarity of form by no means indicates natural affinity; it only indicates similitude of habits and mode of life'.[1]

Locomotion :—Although the muscular movements of fishes have been studied for a long time, the exact significance of these movements has only been realized during recent years as a result of the researches of Gray.[2] In all text-books on ichthyology, the function of locomotion is assigned to the fins; the tail and the caudal fin are regarded as the chief organs responsible for the forward movements of fishes. Breder[3] and Gray (*op. cit.*) have shown that in a fish moving forwards the waves of muscular contraction start from the anteriormost region of the body and the rôle of the caudal fin is to offer resistance to the transverse movement of the fish and to exert a fraction of the forward propulsive thrust. It is thus seen that, according to the latest researches, both the head and the tail-fin are concerned in the locomotion of fishes.

In the light of what is stated above, it is now possible to understand the views expressed on the above-mentioned subjects in *Suśruta*. The passage[4] runs as :—

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[1] Günther, *An Introduction to the Study of Fishes*, p. 36 (Edinburgh, 1880).

[2] Gray, *Journ. Exper. Biol.*, X, p. 88 (1933); *Proc. Roy. Soc. London* (B) CXIII, p. 115 (1933); *Nature*, CXXXI, p. 825 (1933).

[3] Breder, *Zoologica*, IV, p. 159 (1926).

[4] नादेया गुरवो मध्ये यस्मात् पुच्छास्यचारिणः ॥
सरस्तडागजानां तु विशेषेण शिरो लघु ।
अदूरगोचरा यस्मात्तस्मादुत्सोदपानजाः ॥
किञ्चिन्मुक्ता शिरोदेशमत्यर्थं गुरवस्तु ते ।
अधस्ताद्गुरवो ज्ञेया मत्स्याः सारसिजाः स्मृताः ॥
उरोविचरणात्तेषां पूर्वमङ्गं लघु स्मृतम् ।
[इत्यानूपो मत्स्याभिष्यन्दिमांसवर्गो व्याख्यातः ॥ २९ ॥]

nādeyā	*guravo*	*madhye*	*yasmāt*	*pucchāsyacāriṇaḥ* ॥
river (fish)	deeper (bulky)	in the middle	since	tail-snout-movement

sarastaḍāgajānāṃ	*tu*	*viśeṣeṇa*	*śiro*	*laghu*
of the lake-tank (fish)	on the other hand	particularly	head	small

adūragocarā	*yasmāt*	*tasmād*	*utsodapānajāḥ* ॥
of-not-wide expanse	since	hence	spring-pool-(fish)

kiñcin-muktvā	*śirodeśam*	*atyarthaṃ*	*guravas*	*tu*	*te* ।
a little leaving	head portion	extremely	deep (bulky)	on the other hand	they

adhastād	*guravo*	*jñeyā*	*matsyāḥ*	*sarasijāḥ*[1]	*smṛtāḥ* ॥
from below	big (broad)	should be known	fishes	of torrents	traditionally known

urovicaraṇāt	*teṣām*	*pūrvam*	*aṅgaṃ*	*laghu*	*smṛtam* ।
from-moving-with-chest	of them	front	body	small	traditionally known

A free translation[2] of the passage may be given as follows :—

[1] According to Dr. Chhabra, '*Sarasija* (lit. "born-in-lake") is an *avibhaktilopa samāsa* : *i.e.* a compound where the declinatory termination is optionally retainded. *Sarasija* and *saroja* are thus synonyms ; in the latter, however, the termination *i* is dropped.'

'Generally *Saras* denotes "lake", "pool", "pond", "tank" or "spring", but here it must mean something different, as the word in its usual sense has already been used in the foregoing stanza. Moreover, we are dealing with two different body-forms o fishes obviously living in two different habitats. The *saroja* (in *sarastādagajānāṃ*) is one type of fish and *sarasija* is another, as is evident from the description. Dr. Hora informs me that the description of the latter agrees with that of the torrential fishes and, therefore, *saras* is not used here in its usual sense but means a "torrent". The word is derived from the root $\sqrt{sṛ}$ "to flow" (*sarati + iti=saras* "that which flows is called *saras*"). It is thus seen that though in common usage the word *saras* refers to standing pieces of water, literally it means "something flowing". In *Dvirūpakosa*, *saras* is given as a synonym of *nirjhara* as well, which undoubtedly means a "waterfall" or a "torrent". Thus the meaning assigned to *Sarasijāḥ* is even in agreement with that sanctioned by the lexicons.'

[2] Kaviraj Kunja Lal Bhiṣagratna (*An English Translation of the Sushruta Samhita*, I, p. 493, Calcutta, 1907), translates this passage as follows :—

'River-fish are heavy at the middle, owing to the fact of their moving about with the help of their head and tail, while those which are cultured in tanks and ponds (Sarah and Tadāga) are specially light about their heads. Fish, which are found in hill streams or fountains, are extremely heavy about the parts a little below the region of their head, on account of their being confined within narrow limits and the consequent absence of any lengthy sweep. Fish reared in large tanks (Sarasi) are lighter in the foreparts of their body and heavy in their lower parts, as they put their entire pressure upon their breast at the time of swimming.'

The river fish are bulky in the middle because they move with their head and tail; the lake and tank fish are similar to the above but are characterized by a relatively smaller head; the spring and pool fish, as they have not much space to move about, are extremely deep behind the head; the fishes of the torrents are traditionally well known by the possession of two characteristics, the greatly flattened body on account of their habit of crawling with the chest, and a relatively reduced anterior part of the body.

According to *Suśruta*, the freshwater fishes are grouped into 4 ecological 'Formations', (i) river fishes (=animals of slowly flowing streams),[1] (ii) lake and tank fishes or fishes of the natural and artificial large stretches of water (=animals of lakes and other large pieces of water), (iii) spring and pool fishes or fishes of the natural and artificial small stretches of water (=animals of pools, ponds, springs and other small, confined stretches of water) and (iv) torrential fishes (=animals of rapidly flowing streams). It is further shown that the body forms of fishes are characteristic of these habitats—wedge-shaped form in rivers, smaller size of head in lake and tank fishes, lengthening of the vertical axis in spring and pool fishes, and lastly the greatly flattened and depressed form in torrential fishes. It is remarkable that even reasons are assigned for the correlation between the different forms and the corresponding habitats—river fishes are wedge-shaped because they move with their head and tail (fast-moving fishes); the vertical axis of the spring and pond fishes is lengthened because they do not move about much and torrential fishes are greatly flattened for they crawl with their chests closely applied to rocks and boulders. It is still further remarkable that the ancient Hindus were familiar with the fact that in the movements of fishes both the anterior and the posterior parts are concerned. Breder (*op. cit.*) discovered this in 1926 and Gray (*op. cit.*) has now demonstrated definitely that in the locomotion of fishes the initial movement starts from the anteriormost region of the body and that the tail also exerts a fraction of the forward propulsive thrust. It is thus seen that the ancient Hindus were more or less familiar with our present conceptions of the principles of

Presumably in the absence of sufficient knowledge regarding the body forms of fishes, the author of the above translation could not give appropriate meanings of *Sarah* (*Saras*) and *Sarasi* (locative form of *Saras*) occurring in connection with two types of body forms. In the Sanskrit language, as in other languages also, it is not unusual that one and the same word may have different meanings; its exact significance, however, can only be judged with reference to the context. *Saras* means a large expanse of water, such as a tank or a lake, and also a brook or a torrent (*vide* note 1 on p. 5). The translation of *Utsa* and *Udapana* as hill streams or fountains is also defective. In fact, to understand the above passage a knowledge of fishes is as essential as that of the language.

[1] See Pearse's classification of freshwater habitats (*vide supra*, p. 3.)

ecological segregation and fish locomotion. They also knew the laws governing the correlation between body-forms and habitats, body-forms and habits, and habitats and habits. It is surprising that after years of hard work we are now discovering certain principles of animal biology which appear to be so clearly enunciated in the passage from *Suśruta* quoted above.

The observations on torrential fishes, with which I am fairly familiar, are most illuminating. It is known that all hill-stream fishes, which use their chests and paired fins for adhesion, are greatly flattened and the flattening is directly proportional to the rapidity of the current.[1] The organs of the anterior part of all hill-stream animals are either reduced or modified, for this is the portion against which the rapid current strikes and it is not safe to leave this part free to be swayed by the eddies of the current. Suśruta's mention of the flattening of the body, crawling with the chest and the reduction of the anterior part is fully borne out by my researches on torrential populations.

The exact age of Suśruta's monumental work on the Indian system of medicine is very difficult to determine. Bhiṣagratna (*op. cit.*) has, however, discussed the age and personality of Suśruta and seems to have come to the tentative conclusion that 'At all events Nágárjuna who redacted the Sushruta Samhitá lived about the latter part of the fourth century before the Christian era; and the original or Vridha Sushruta must have been written at least two centuries earlier in order to acquire that hoary authority and prescription of age, which alone could have given its right to a recension at the time' (pp. iii, iv). In connection with the observations on hill stream fishes, Suśruta makes it clear that the characteristics enumerated by him were traditionally well known in his time, so there seems no doubt that several centuries before the Christian era Hindus had discovered what the modern researches are bringing to light now.

This article is written in the hope that it will stimulate Oriental scholars to collect old Sanskrit and Pali texts bearing on Indian Ichthyology. A careful analysis of such texts—in reference to animals in general—in the light of modern advances would alone enable us to confirm or controvert the views of the European writers in reference to the zoological knowledge of the ancient Hindus.

In the end I have to thank my cousin, Dr. Bahadur Chand Chhabra, for his kind and valuable help in connection with the translation of the Sanskrit text. I am grateful to Dr. B. Prashad for going through the paper.

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[1] Hora, *Phil. Trans. Roy. Soc. London* (B) CCXVIII, pp. 231–240 (1930); *Mem. Ind. Mus.*, XII, pp. 323–325 (1932).

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ARTICLE NO. 2.

Some of the Common Flowering Plants of the Hyderabad State; their distribution, economic and medicinal importance.

By M. SAYEEDUD-DIN.

CONTENTS.

INTRODUCTION.

About a year after my return from Edinburgh in August, 1929, I set myself to work out the flora of the Hyderabad State, Deccan. My interest in Systematic Botany was mainly created by my inspiring teacher, Sir William Wright Smith, Regius Keeper of the Royal Botanic Garden, and Professor of Botany, University of Edinburgh. His advice to me was to collect and identify the chief plants of the Hyderabad State, and to publish a report as early as possible. He strongl believed that such a piece of work would be of immense value to the young students who would thus be able to acquaint themselves with the local plants and develop general interest in Botany.

The present paper is a record of some of the plants found either under cultivation or growing wild in the Hyderabad Dominions. I have at present restricted my attention mainly to the city environs and Pakhal, a *talukha* of the Warangal District of Hyderabad. It is interesting to note that the Pakhal forest, extending over several miles, provides a diversity of plant life. The rich flora of this region and the neighbouring places, viz. Muluk, etc. would, however, take a considerable time to work out in detail.

The arrangement of the families is in accordance with the classification adopted by Bentham and Hooker in '*Genera Plantarum*'. Altogether 302 species belonging to sixty-two families of Dicotyledons have been recorded, out of which about 206 are of medicinal value. The remarks about the various species and the local uses mentioned are the results of my investigation. Sometimes more than one plant is given the same vernacular name, hence the vernacular names may not

be strictly adhered to. Thus '*Gorak-imli*' is the local name for *Pithecolobium dulce* (Mimosoideæ), whereas the same name is given to *Adansonia digitata* (Monkey-bread tree or *Baobab*), etc.

ACKNOWLEDGMENTS.

I am greatly indebted to my assistant Mr. Abdus-Salam, for the collection of some of the material and the general help he has rendered me in the systematic classification of the specimens, and to Dr. B. K. Das for his suggestions. My sincere thanks are due to Mr. K. P. Biswas, Curator of the Herbarium, Royal Botanic Garden, Calcutta, for his kindly reading through the typescript and for his valuable suggestions which have been incorporated in this paper, and to Dr. S. L. Hora of the Indian Museum, Calcutta, for kindly correcting the proofs. I am also indebted to Mr. Mayuranathan of the Madras Museum for kindly verifying some of my identifications and to Mr. Abur Rahman Khan for some of the specimens.

GENERAL TOPOGRAPHY AND PHYSICAL FEATURES OF THE HYDERABAD STATE.

Hyderabad, with an area of 82,698 square miles, is one of the largest of the Indian States, and lies between 15° 10′ and 20° 40′ N. and 74° 40′ and 81° 35′ E. It forms a polygonal tract occupying almost the centre of the Deccan table-land with the Khandesh District of the Bombay Presidency on the north-west, Berar and Central Provinces touching it on the north, and bounded on the south by the Krishna and the Tungabhadra rivers, which separate it from the Guntur, Kurnool, and Bellary Districts of the Madras Presidency. On its west lie Ahmadnagar, Sholapur, Bijapur, and Dharwar Districts of the Bombay Presidency, and on the east it is bounded by the Wardha and the Godavari rivers, and the Krishna District of Madras. It has a little more than two and a half times the area of Ireland, or $1\frac{2}{5}$ of the combined areas of England and Wales.

The average elevation of this extensive plateau is about 1,250 feet above the sea level with a few summits here and there rising from 2,500 to 3,500 feet. Roughly speaking, it is divided into two large and nearly equal, but geologically and ethnologically quite distinct, divisions separated from each other by the rivers Majra and Godavari. The portion to the north and west belongs to the trappean region (that is to say, the Marathwari and Kanarese regions), while the south and east are granitic and calcareous. The former or the black cotton soil country (as it is commonly called) is a land of wheat and cotton, while the latter (or the Telangana side) is a land of rice and tanks. The black cotton soil is, of course, richer than the granitic one, retaining moisture for a considerably long time, and in spite of cliffs, crags and undulating hills, is, therefore,

covered with luxuriant vegetation. In the granitic region of the Telangana Districts, the hills are practically destitute of vegetation, but the plains are covered with low plants and shrubs of every description. In this region the soil for the most part is sandy, and does not retain water. The surface of the country has a general slope from north-west to south-east, the main drainage being in this direction.

Chief Hill and Mountain Ranges of the State.—The Balaghat range extends almost east and west of Hyderabad, with a length of 200 miles and an average width of 4½ miles from east of Nander District to Ashti in Bhir District. The Sahyadri Parvat runs along the north, from Nirmal in Indur District in the east, reaches Ajanta after passing Parbhani and the Provinces of Berar, and proceeding further in westerly direction it finally reaches Khandesh in the Bombay District. Its total length within the State is about 250 miles, of which about 100 miles is styled as the Ajanta Hills. In addition, the Jalna Hills, Kandikal Gutta (or Sirnapalli) and other smaller ranges run through the State.

Rivers of the Hyderabad State.—The principal rivers are the Godavari and the Krishna (Kistna), with their tributaries the Tungabhadra, the Purna, the Penganga, the Manjra, the Bhima and the Maner. In addition, there are many smaller streams, such as, the Musi, the Windi, the Munair, and others. The Godavari enters the State at Phultamba in Aurangabad District, flows through it and the districts of Parbhani, Nander, Indur, and Adilabad for a distance of 500 miles, and changing its course at north-east corner of Elgandal and Warangal Districts, until at Paranthpalli, in the latter district, it enters the Godavari District of Madras. It is joined by Manjra, which rises in the Patoda Taluka of Bhir District, after a course of 387 miles through Bhir, Osmanabad, Bidar, Medak, Nander, and Indur Districts. The Krishna crosses the border of the Bijapur District of the Bombay Presidency at Echampet in Lingsugur District, and taking a south-easterly course traverses the Districts of Lingsugur, Raichur, Mahbubnagar, Nalgonda, and Warangal, forming the southern boundary of the last three districts, and consequently of the State. The Penganga rises in the Sahyadri Parvat, and runs eastwards along the north of Hyderabad, separating Parbhani, Nander and Sirpur Tandur (now Adilabad) Districts from the southern parts of Berar. In Sirpur Tandur it flows along the western and northern borders until it falls into the Wardha river, north of the Rajura taluka.

The geological formation of the State are the recent and ancient alluvia, laterite, Deccan trap, Gondwana, Kurnool and Cuddapah and Archæan, of which the most largely developed are the Deccan trap and the Archæan, covering immense areas in the north-western and south-eastern portions of the territory, respectively.

This communication deals with the vegetation of the Warangal District of the Telangana side in detail, and I have selected one of its Talukas or sub-districts, viz. Narasampet as a suitable place to start with.

The average temperature, rainfall, barometric conditions, etc. for the principal districts under investigation are given in the following tables :—

I.

Average Temperature (*in degrees—Fahrenheit*).

Station	Height above sea-level in feet	January		May		July		November	
		Mean	Diurnal range	Mean	Diurnal range	Mean	Diurnal range	Mean	Diurnal range
Hyderabad[1] ..	1,690	72·1	25·8	91·9	23·2	80·4	14·4	73·5	22·1
	1,817·9	72·7	25·4	92·3	24·2	80·0	15·1	72·9	23·2
Warangal (Hanum-Konda).	871	75·1	23·3	93·2	22·0	82·4	13·0	75·6	21·8

II.

Average Rainfall (*in inches*).

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total for the year
Hyderabad ..	0·11	0·21	0·61	0·91	0·96	4·43	6·14	6·98	6·62	3·58	1·45	0·37	32·37
	0·28	0·70	0·47	1·10	0·80	4·24	5·62	4·67	7·37	2·82	1·37	0·26	29·53
Warangal (Hanum-Konda).	0·25	0·27	0·74	0·50	0·76	4·58	8·36	7·43	6·93	2·51	1·20	0·26	33·79

N.B.—For Warangal District latest data were not available.

[1] All figures given for Hyderabad in the second row of tables I and II and the whole of the table III on p. 13 represent values for the last seven years ending 1931, whereas others in tables I and II indicate those for the 10 and 25 years respectively ending 1901 (*Imp. Gaz. Ind.*, Vol. XIII, p. 234, 1908). I am grateful to Mr. T. P. Bhaskaran, M.A., F.R.A.S., Director of the Nizamiah Observatory, H.E.H. the Nizam's Government, Hyderabad (Deccan), for placing the latest information relating to the average temperature, rainfall, barometric conditions, etc. at my disposal.

III.

Average barometric condition, i.e. barometric pressure in inches and movement of wind in 24 hours.

Station	January		May		July		November	
	Pressure	Wind Velocity	Pressure	Wind Velocity	Pressure	Wind Velocity	Pressure	Wind Velocity
Hyderabad[1] ..	28·362	85	28·178	162	28·077	269	28·348	95

Warangal District.

Warangal, formerly known as Khammamett, lies between 16° 38′ and 18° 36′ N., and 78° 50′ and 81° 33′ E., and has a total area of 9,729 sq. miles. It is bounded by the Central Provinces, District of Chanda and the Madras Districts of Godavari and Krishna on the east and south-east, and by the Hyderabad Districts of Nalgonda, Atraf-i-Balda, Medak, and Kareemnagar on the south, west and north respectively. A range of low hills runs from Pakhal and Singareni to Ashwaraopet in the south-east, bounding the lower Godavari valley. The Kandikal Gutta range, 50 miles in length, extends from the south-east to Chinnur in the Adlibad District. Ten miles north-west of Warangal are the Chandragiri hills and 14 miles west of it, the well-known iron hills of Hasanparti. The country around the town of Hanamkonda is about 1,700 feet above the sea-level, but the average elevation of the district is only 870 feet. The whole country is dotted with isolated hills.

The two principal rivers within the Warangal District are the Godavari and the Krishna. The former touches the district north of Mangapet in the Pakhal Taluka, and, flowing in a south-

[1] All figures given for Hyderabad in the second row of tables I and II on p. 12 and the whole of the table III represent values for the last seven years ending 1931, whereas others in tables I and II indicate those for the 10 and 25 years respectively ending 1901 (*Imp. Gaz. Ind.*, Vol. XIII, p. 234, 1908). I am grateful to Mr. T. P. Bhaskaran, M.A., F.R.A.S., Director of the Nizamiah Observatory, H.E.H the Nizam's Government, Hyderabad (Deccan), for placing the latest information relating to the average temperature, rainfall, barometric conditions, etc. at my disposal.

easterly direction along its eastern boundary, leaves it at the south-east of Paloncha, where it enters the Godavari District of Madras, after a course of 113 miles within the Warangal District. The Krishna passes along the southern boundary of the Khammamett Taluka for a short distance only. There are, besides these, many minor rivers and streams. The Pakhal lake in the Pakhal Taluka has been formed by erecting a dam, 2,000 yards long, across the Pakhal river, between two low head lands. The lake is 8,000 yards long by 6,000 yards broad, and, when full, covers an area of 13 square miles.

Agriculture in the Warangal District.—The soil in some parts is granitic and in others, viz. Pakhal, Paloncha, Khammamett, etc. it is black and rich. The staple food crops are *jawar* (*Sorghum vulgare*), *bajra* (*Pennisetum typhoideum*), maiz (*Zea mays*), wheat (*Triticum vulgare*), tobacco (*Nicotiana tabacum*), etc. Cotton is grown to a small extent in all talukas. Other crops are oil-seeds and pulses. Detailed information about the forest trees is given under each family.

SYSTEMATIC ACCOUNT.

I. MAGNOLIACEÆ.

1. **Michelia Champaca** Linn., *F.B.I.*, I, p. 42.

Vern. Names : Champa (Hind.) ; *Sampangi* (Tel.).

Habitat : Commonly grown in gardens, and near Hindu temples for its sweet-scented flowers.

Uses : The Hindus use this plant in their religious ceremonies. The wood, which is of a light olive-brown colour, is durable, takes on good polish, and is used for making furniture. A very refreshing perfume is extracted from the flowers, which are also used in the treatment of leprosy, boils, itch, and gonorrhœa. The flowers and fruits are used in dyspepsia, nausea, and fever. The perfumed oil extracted from the flowers is useful for application in cephalalgia, ophthalmia, and gout. The bark is regarded as an astringent, stimulant, febrifuge and expectorant. The root is described as purgative.

II. ANONACEÆ.

2. **Anona squamosa** Linn., *F.B.I.*, I, p. 78. (Custard Apple.)

Vern. Names : Sitaphal, Sharifa (Hind.) ; *Sitapalam* (Tel.).

Habitat : It is now naturalised in India and is found in a wild state throughout Hyderabad. It is cultivated for its fruit.

Uses : The fruit is very much relished. Medicinally, the ripe fruit is considered a maturant. Bruised and mixed with salt, it is applied to tumours to induce and hasten suppuration. The dried raw fruit, powdered and mixed with gram flour, is used to destroy vermin. The bruised leaves with salt make a cataplasm to induce suppuration (Atkinson). The root is said to be a strong purgative and is often used in cases of acute dysentery. The seeds are a powerful irritant of the conjunctiva (Kirtikar).

3. **Anona reticulata** Linn., *F.B.I.*, I, p. 78. (Bullock's Heart).

Vern. Names : Ramphal (Hind.) ; *Ramsitapalam* (Tel.).

Habitat : Cultivated in gardens.

Uses : The bark is considered a powerful astringent. The fruit though largely eaten locally, is not half as tasty as that of *A. squamosa.*

4. **Anona muricata** Linn., *Cooke*, I, p. 15. (The Sour-sop.)

Vern. Name : Mamphal (Hind.).

Habitat : Like the preceding species it is only occasionally found growing in gardens. This species was introduced into India from Tropical America.

5. **Artabotrys odoratissimus** R.Br., *F.B.I.*, I, p. 54. (Green Champa.)

Vern. Name : Madanmast (Hind.).

Habitat : Often cultivated in gardens throughout the Dominions for its sweet-scented flowers ; said to grow wild in some parts. Flowers in winter.

6. **Polyalthia longifolia** Benth. and Hooker, *F.B.I.*, I, p. 62.

Vern. Names : Asok, Ashoka (this is popularly called *Ashoka*, though the real *Ashoka* of Sanskrit authors is *Saraca indica*) ; *Ashuphal* (Hind.) ; *Devadaru* (Bengali and Tel.).

Habitat : Often planted near Hindu temples. Not wild.

Uses : It is used as a febrifuge in the Balasore District of Orissa (Sir W. W. Hunter). Its wood is commonly used for packing cases.

III. MENISPERMACEÆ.

7. **Tinospora cordifolia** Miers, *F.B.I.*, 1, p. 97.

Vern. Names : Gul-bel, Giloe (Hind.) ; *Gulancha* (Beng.) ; *Tippa tiga* (Tel.).

Habitat : Found in most forests throughout the Dominions. Also cultivated because of its medicinal properties.

Uses : According to Kirtikar, the medicinal value of this plant is due to a small quantity of Berberine present in it. It is used as an aphrodisiac, alterative and tonic. A starch is obtained from the roots and stems known as '*sat-i-giloe*', which appears like Arrow-root. It is useful in chronic diarrhœa, in some forms of dysentery, in intestinal irritability, weakness of the stomach, and heat of stomach causing temperature, burning of palms and soles, in rheumatism and in gonorrhœa.

8. **Cocculus villosus** DC., *F.B.I.*, I, p. 101.

Vern. Names : Farid-butti (Hind.) ; *Diar* (Mar.).

Habitat : Quite common in hedges on the Marhatwari side.

Uses : The juice of the leaves, mixed with water, has the property of coagulating into a green jelly-like substance, which

is taken internally, sweetened with sugar, as cure for gonorrhœa (Kirtikar).

According to Roxburgh, 'A decoction of the fresh roots, with a few heads of pepper, in goat's milk, is administered for rheumatic and old venereal pains; half a pint every morning is the dose. It is reckoned as heating, laxative, and sudorific'.

The root is said to be alterative and a good substitute for sarsaparilla.

IV. NYMPHÆACEÆ.

9. **Nymphæa Lotus** Linn., *F.B.I.*, I, p. 114. (Water Lily.)

Vern. Names: *Kamal*, *Kanval* (Hind.); *Salu* (Beng.).

Habitat: Cultivated in ponds in some parts of Hyderabad. The pond of the Public Gardens, Hyderabad, is full of it.

V. PAPAVERACEÆ.

10. **Argemone mexicana** Linn., *F.B.I.*, I, p. 117.

Vern. Name: *Pila dhatura* (Hind.).

Habitat: Quite common in waste places, cultivated fields, along roadsides, etc.

Uses: The yellow juice of the plant is used in jaundice, dropsy and cutaneous affections. The seeds are laxative. demulcent, etc. being used in coughs, asthma, and other diseases. The oil is a strong purgative and expectorant: and the root an alterative tonic.

11. **Papaver somniferum** Linn., *F.B.I.*, I, p. 117. (Opium Poppy.)

Vern. Names: *Afeun* (Arabic); *Afim* (Hind.) for the alkaloid only, *Khash-Khash* (Hind.) for seeds only.

Habitat: Cultivated in very limited areas. Regulations have been imposed by the Government on its cultivation and consumption.

Uses: Opium (*Afim*), which is obtained by cutting notches in the half ripe capsules, and collecting the latex exuding from them, is an intoxicant and stimulant. It is sold in licensed shops. In big doses it proves fatal. Its therapeutic uses are too well known to be described in detail here. The seeds known as '*khash-khash*' or '*Posta dana*' are used in curries here, and in some sweets also. An infusion prepared from the poppy heads, is used as a soothing application for bruises, swellings, inflammations, etc. (For details refer to *Indigenous Drugs of India* by Col. R. N. Chopra.)

VI. CRUCIFERÆ.

12. **Brassica nigra** Koch, *F.B.I.*, I, p. 156.
(Black Mustard.)

Vern. Names: *Rai*, *Kali rai* (Hind.); *Avalo* (Tel.).

Habitat: Commonly cultivated for its seeds.

Uses: The use of the seeds in poultices is well known. Mustard poultices are efficaceous in inflammations, neuralgic and rheumatic affections.

The seeds taken internally are laxative. The fresh oil is a stimulant and mild counter-irritant when applied externally, hence it is useful in mild attacks of sore-throat, chronic muscular rheumatism, etc. (Kirtikar).

13. **Brassica Rapa** Linn., *F.B.I.*, I, p. 156.
(The common turnip.)

Vern. Names: *Shaljam*, *Shalgam* (Hind.).

Habitat: Very commonly and extensively cultivated throughout the Hyderabad State.

Uses: The taproot is eaten after cooking, so also the fruit (*singri*).

14. **Brassica oleracea** Linn., Watt Dict. *Econ. Prod. Ind.*, V, p. 533.

The following varieties are commonly grown for food throughout Hyderabad :—

(*a*) **capitata** (cabbage).
Vern. Name: *Bund-gobhi* (Hind.).

(*b*) **caulorapa** (*Knol-khol* or *Kohl-rabi*).
Vern. Name: *Knol-khol.*

(*c*) **botrytis** (cauliflower).
Vern. Name: *Phool-gobhi* (Hind.).

15. **Raphanus sativus** Linn., *F.B.I.*, I, p. 166.
(Radish.)

Vern. Names: *Mooli* (Hind.); *Mullangi*, *Muli-gadda* (Tel.).

Habitat: Commonly cultivated for its taproot.

Uses: The root (*Muli*) as well as the fruit (*Singri*) is curried.

VII. CAPPARIDEÆ.

16. **Cleome viscosa** Linn., *F.B.I.*, I, p. 170.

Vern. Name: *Hulhul* (Hind.).

Habitat: Very wild throughout the Dominions.

Uses: The seeds, leaves and roots are used in medicine. Seeds are considered effective for removing round worms.

17. **Capparis horrida** Linn., *F.B.I.*, I, p. 178; Cooke, *Fl. Bomb. Pres.*, Part 1, p. 48.

Vern. Name: *Ardanda* (Hind.).

Habitat: Wild everywhere. The material was collected from hedges and fields in the vicinity of the city.

Uses: A cataplasm made from the leaves is used in boils, swellings and piles (Atkinson). The bark, along with country spirit is given in cholera (Campbell). For further information see Watt, *Dict. Econ. Prod. Ind.*, Vol. II, p. 132.

VIII. PORTULACEÆ.

18. **Portulaca oleracea** Linn., *F.B.I.*, I, p. 246. (Indian Purslane.)

Vern. Names: *Kulfa, Khurfa* (Hind.); *Boddu-pavili-kura* (Tel.).

Habitat: Commonly cultivated for its economic and medicinal uses. Also grows as an escape in cultivated grounds and gardens.

Uses: The shoots are curried. It is supposed to be a refrigerant and alterative. As an article of diet it is useful in liver disease and scurvy. The seeds are believed to be vermifuge; they are also useful in urinary diseases, dysentery and diarrhœa. 'The juice of the herb is applied with advantage to prickly heat, also to the hands and feet when a burning sensation is felt in them; it is taken internally in spitting of blood.'

19. **Portulaca quadrifida** Linn., *F.B.I.*, I, p. 247.

Vern. Names: *Khatte-chaval-ki-bhaji* (Hind.); *Peddapavili-kura* (Tel.).

Habitat: A common weed throughout the Hyderabad State.

Uses: The shoots are curried. The leaves and seeds are used in medicine and possess properties identical to those of the above species.

IX. MALVACEÆ.

20. **Hibiscus esculentus** Linn., Cooke, *Fl. Bomb. Pres.*, I, p. 112. (Lady's finger.)

Vern. Names: *Bhindi* (Hind.); *Penda, Benda-kaya* (Tel.).

Habitat: Cultivated all over the Dominions.

Uses: The tender fruits are used as vegetables. The fruits and seeds are of medicinal importance. They are described by the Indian physicians as cold and moist. The fruit is good for irritating cough. The mucilage from the fruits and seeds is useful in gonorrhœa and irritation of the genito-urinary system. Locally the mucilage is often mixed with powdered limestone to make it sticky for white-washing purposes.

21. **Hibiscus cannabinus** Linn., *F.B.I.*, I, p. 339.

Vern. Names: *Ambada* (Hind.); *Ghongu-kura* (Tel.).

Habitat: Cultivated throughout the State.

Uses: The leaves are used in curries. The seeds, leaves and juice are of medicinal importance. The seeds are said to be fattening, and are used as an external application for pains and bruises. The juice of flowers is a popular remedy for biliousness. The leaves are used as purgative.

22. **Hibiscus sabdariffa** Linn., *F.B.I.*, I, p. 340.
(The 'Roselle' of Indian Gardens.)

Vern. Names: *Lāl-Ambada* (Hind.); *Erra-gomkaya* (Tel.).

Habitat: Cultivated throughout the State.

Uses: The dried calyx is used in curries. The seeds, fruits and leaves are used in medicine. The seeds are useful in dyspepsia, etc. The fruit is anti-scorbutic. The leaves are regarded as emollient, and are often curried.

23. **Hibiscus rosa-sinensis** Linn., *F.B.I.*, I, p. 344.
(Shoe-Flower.)

Vern. Names: *Gurhul, Jasund, Jasoon* (Hind.); *Jasvan* (Mar.).

Habitat: Cultivated in gardens and in houses almost all over the State.

Uses: The juice of the petals is used for colouring sugar and confectionary pink (Kirtikar) and to blacken leather shoes (Masters). The flowers, leaves and root are of medicinal importance. The flowers, owing to their brilliant colour are also very commonly used in temples. The root is valuable in coughs (S. Arjun). An infusion of the petals is a demulcent and refrigerant drink in fevers (Moodeen Sheriff). The leaves are considered emolient and aperient (Murray).

24. **Hibiscus syriacus** Linn., *F.B.I.*, I, p. 344.

Habitat: Cultivated throughout the Dominions as an ornamental plant.

25. **Malva sylvestris,** *F.B.I.*, I, p. 320.

Vern. Name: *Vilayatikangoi-ka-jhar* (Hind.).

Habitat: I have seen it growing wild round about Hyderabad.

Uses: All parts of the plant are used medicinally for their cooling and mucilaginous properties.

26. **Thespesia populnea** Soland ex Correa., *F.B.I.*, I, p. 345. (Tulip or Portia tree, Bhendy tree.)

Vern. Names: *Bhendi-ka-Jhar*, *Paras-pipal* (Hind.).

Uses: The bark, roots, leaves, flowers, fruits and seeds are all used in medicine. The yellow juice of the fruit is useful in cutaneous diseases. A decoction of the bark is given internally as an alterative (Ainslie). In Concan, the flowers are employed in the cure of itch (Kirtikar). The leaves are employed as a local application to swollen and inflamed joints (Dymock).

27. **Gossypium herbaceum** Linn., *F B I.*, 1, p. 346. (Indian Cotton).

Vern. Names: *Rui*, *Kapas* (Hind.), *Pratti* (Tel.), *Kapus* (Mar.).

Habitat: Cultivated extensively on the Marathwari side (Aurangabad, Jalna, Parbhani, and in many other districts of the State).

Uses: Apart from the economic importance of cotton which this plant provides us with, almost all its parts, viz., bark, seeds, leaves, flowers and root-bark are of great medicinal value. The cotton wool is applied to burns, cuts, etc. The seeds are employed to procure abortion. They are also given as food to cattle, because they increase the secretion of milk. They are also said to be an antidote for snake poison. A poultice of the flowers is applied to burns, etc. and their syrup has a stimulating and an exhilarant effect. The juice of the leaves is a tonic, and is used in dysentery, diarrhœa, and fever. The root is diuretic and demulcent.

28. **Gossypium barbadense** Linn., *F.B.I.*, I, p. 347.

Habitat: I found this rare plant growing in the city of Hyderabad. It has not been recorded in the *Forest Flora of Hyderabad* (Partridge), in which not only the typical indigenous forest plants are described but some of the other common plants as well.

Uses: The cotton is used for stuffing pillows, etc.

29. **Eriodendron anfractuosum** DC., *F.B.I.*, I, p. 350.

Vern. Names: Safed semul, Hattian (Hind.); *Buruga* (Tel.); *Shameula* (Mar.).

Habitat: Found towards Aurangabad side. Not very common.

Uses: The silky cotton, which is really produced from the inner wall of the capsule, is used for stuffing pillows and cushions. The gum is useful for bowel complaints. The leaves, roots and raw fruits are of medicinal value. 'The leaves are ground into a paste and administered in gonorrhœa' (Surgeon Thomas). The taproot is used in gonorrhœa and dysentery. The unripe fruits are regarded as demulcent and astringent.

30. **Bombax malabaricum** DC., *F.B.I.*, I, 349. (Silk Cotton tree.)

Vern. Names: Semul (Hind.); *Mundlaburaga-chettu, Burga* (Tel.); *Kanta-Sair* (Mar.).

Habitat: Very common throughout the Dominions. It is extremely common and abundant in Pakhal.

Uses: The soft whitish wood is employed in making boxes, toys, fishing floats, etc. The trunks are often hollowed out to make canoes, especially on the Godavari river. The cotton is used for stuffing pillows and quilts. The gum, seeds, fruits, root-bark and flowers are of medicinal importance The gum is used as an aphrodisiac, useful in gonorrhœa, dysentery and diarrhœa. The young fruit is stimulant, diuretic, tonic, aphrodisiac, expectorant, etc. The taproot is demulcent. tonic, slightly diuretic and aphrodisiac (Kirtikar).

31. **Adansonia digitata** Linn., *F.B.I.*, I, p 348. (Monkey-bread tree or Baobab.)

Vern. Names: Gorak-imli, Hatti-Kattian (Hind.), *Sima-chinta* (Tel.), *Gonik-chintz* (Mar.).

Habitat: I have seen a few trees round about the city of Hyderabad, but it is common in Aurangabad (Marhatwari District). Its original home is Africa.

Uses: Leaves, bark and fruits are used in medicine. The yellowish fruit pulp, which becomes dry and pith-like when ripe, is acid and makes a very pleasant refrigerant drink. It is astringent in diarrhœa, like gallic acid (Kirtikar). Locally it is used in dysentery. Walz has given the name 'Adansonin' to an active principle he extracted from the bark. According to Moodeen Sheriff, the bark is useful to some extent in simple and complicated cases of continued and intermittent fevers. The fibre is also useful.

32. **Abutilon indicum** G. Don., *F.B.I.*, I, p. 326.

Vern. Names: Kanghi (Hind.); *Kungain* (Mar.).

Habitat: Common, especially abundant on the Marhatwari side.

Uses: An infusion of the leaves or of the roots is prescribed in fevers as a cooling medicine (Ainslie). A decoction of the leaves is used as a mouth-wash in cases of tooth-ache and tender gums, and also in gonorrhœa and inflammation of the bladder (Kirtikar). The seeds are effective in coughs.

X. TILIACEÆ.

33. **Grewia asiatica** Linn., Roxburgh, *Fl. Ind.*, II, p. 586.

Vern. Names: Falsa (Hind.); *Phutiki* (Tel.).

Habitat: Cultivated in gardens for its fruit throughout the Hyderabad State. Messrs. Kanjilal and Duthie's description of this plant tallies with the specimens I have examined, but so far I have not met with a tree of *Grewia Grewia asiatica* growing here can very safely be regarded as a shrub.

Uses: The drupaceous fruits are reddish-brown when raw, and bluish black when quite ripe. They are widely eaten and also made into a delicious *Sherbet*[1] with water and sugar. Dr. Stewart says that an infusion of the bark is used as a demulcent and according to Rev. A. Campbell the Santals use the root-bark for pustular eruptions and sores.

34. **Grewia tiliæfolia** Vahl., Roxburgh, *Fl. Ind*, II, p. 587.

35. **Grewia populifolia** Vahl., *F.B I.*, I, p. 358

36. **Grewia pilosa** Lamk., Roxburgh, *Fl. Ind.*, II, p. 587.

37. **Grewia salvifolia**, *F B.I.*, I, p. 386.

XI. LINEÆ.

38. **Linum usitatissimum** Linn., *F.B.I.*, I, p. 410.

Vern. Names: Alsi (Hind), *Atasi* (Tel.); *Alshi* (Mar.).

Habitat: Cultivated in several parts of the Dominions.

Uses: The seeds and flowers are of great medicinal importance. Linseed poultice is recommended for gouty and rheumatic swellings. Flowers are said to be a tonic for heart.

[1] Any type of cold drink prepared out of fruit-juice is called '*Sherbet*'.

Linseed oil is much used in medicine as well as for polishing furniture.

39. **Erythroxylon monogynum** Roxb., *F.B.I.*, I, p. 414.
(Bastard Sandal.)

Habitat: Common in the forests along Godavari on the Marathwari side.

Uses: Leaves, wood, and bark are used in medicines (Kirtikar). There is hardly any doubt as to the wood being used as a substitute for sandal. The leaves are said to be eaten in famine (Dr. Bidie and E. A. Partridge). An infusion of the wood and bark is stomachic, diaphoretic and stimulant diuretic, useful in light cases of dyspepsia and prolonged fever. The leaves are refrigerant (Moodeen Sheriff, *cf.* Kirtikar).

XII. MALPIGHIACEÆ.

40. **Hiptage Madablota** Gærtn., *F.B.I.*, I, p. 418.

Vern. Names: *Madhavilata* (Hind.); *Madhavi* (Mar.) *Madhavi tige* (Tel.).

Habitat: It is found throughout the hotter parts of India and Ceylon. In Hyderabad it is frequently found in gardens.

Uses: 'The leaves are esteemed useful in cutaneous diseases and the juice is specially mentioned by Moodeen Sheriff as an effectual insecticide, and a valuable application in scabies. Useful in chronic rheumatism and asthma.' (Watt. *Dict Econ. Prod.*, I, p. 253.) The leaves are eaten by cattle.

XIII. ZYGOPHYLLEÆ.

41. **Tribulus terrestris** Linn., *F.B.I.*, I, p. 423.

Vern. Name: *Gokru* (Hind.).

Habitat: Very wild throughout Hyderabad, growing in fields and gardens.

Uses: The entire plant is medicinal, especially the fruit and leaves. The fruit is regarded as cooling, diuretic, tonic and aphrodisiac (Kirtikar, Vol. I., p. 250). An infusion of the stems is taken for gonorrhœa (Stewart).

XIV. GERANIACEÆ.

42. **Averrhoa Carambola** Linn., *F.B.I.*, I, p. 439.

Vern. Names: *Kamrakh*, *Karmal* (Hind.); *Karomonga* (Tel.).

Habitat: Extensively cultivated in gardens throughout the Dominions for its fruits.

Uses : There are two varieties, one with sweet fruits, and the other with sour fruits. The latter are used in curries, and are pickled. The juice is used for removing iron-mould stains from linen. 'The acid dried fruit is given in fevers' (Irvine, p. 55). It is cooling and possesses anti-scorbutic properties (Watt's *Dictionary*, I, p. 360). 'The ripe fruit which contains Oxalic acid is a good remedy for bleeding piles (Internal piles). It is also good in relieving thirst and febrile excitement.' (Moodeen Sheriff, *cf.* Kirtikar, Vol. I, p. 238.)

43. **Averrhoa Bilimbi** Linn., *F.B.I.*, I, p. 439.

Vern. Names : Kamaranga (Beng.), *Bilimbi, Belambu* (Hind.), *Vilimbi* (Tel.).

Habitat : Less commonly cultivated than *A. carambola*. I have seen more trees on the Aurangabad side than anywhere else in the Dominions.

Uses : Raw fruit is very acidic, made into pickles, also used in curries. Its juice is used for removing iron-mould stains from clothes. Much the same medicinal properties as of *A. carambola*, being a useful dietary article in piles and scurvy, relieving thirst, etc.

44. **Impatiens Balsamina** Linn., Cooke, *Fl. Bomb. Pres.*, Part I. p. 174.

Vern. Name : Gul-i-Mehndi.

Habitat : Cultivated in gardens all over as an ornamental plant.

45. **Oxalis corniculata** Linn., *F.B.I.*, I, p. 436.

Vern. Names : Amoti (Hind.) ; *Palla-chinta* (Tel.).

Habitat : Extremely common and a troublesome weed in gardens throughout Hyderabad. In villages its favourite growing place is in shady areas under the mango trees.

Uses : Only the leaves (excluding the petioles) are used as vegetable. The leaves are cooling, refrigerant and stomachic. The fresh juice extracted from them is said to relieve intoxication from *Datura* ; and said to be useful in dysentery and prolapsus of the rectum (Dutt). An infusion of the small leaves is given as a cooling medicine in fevers (Honingberger). It is used externally to remove warts and opacities of the cornea (B. Powell). Curried leaves are said to improve the appetite and digestion of dyspeptic patients. A poultice of the leaves prepared with hot water is very efficient for boils. The leaves are refrigerant and antiscorbutic. (Moodeen Sheriff, *cf.* Kirtikar, Vol. I, p. 236.)

XV. RUTACEÆ.

46. **Murraya exotica** Linn., *F.B.I.*, I, p. 502.

Vern. Name: Kunti (Mar.).

Habitat: Common throughout the Dominions on cultivated lands and in gardens.

47. **Feronia elephantum** Correa, *F.B.I.*, I, p. 516. (Wood apple.)

Vern. Names: Kaweet or *Kaitha* (Hind.); *Elka* (Tel.); *Kawat* (Mar.).

Habitat: Throughout the State. Cultivated for its fruits.

Uses: The pulp of the fruit along with the seeds is eaten. It is sweet and slightly acidic to taste. The fruit is used as a stomachic and stimulant in diseases of children. The unripe fruit is described as astringent and is used in combination with '*bela*' fruits of *Aegle Marmelos* and other medicines in diarrhœa and dysentery. The leaves are a useful remedy in salivation and sore-throat. Bark, leaves, gum and fruit are of medicinal value

48 **Ruta graveolens** Linn. var. **angustifolia**, *F.B.I.*, I, p. 485.

Vern. Names: Sadaf (Hind.); *Sadapa* (Tel.).

Habitat: Quite common all over, cultivated for its leaves.

Uses: The dried leaves are given to children suffering from catarrh. They are also useful in rheumatism. The herb and oil are also of medicinal importance, being stimulants chiefly of the uterine and nervous systems.

49. **Citrus medica** Linn, *F.B.I.*, I, p. 514.

Vern. Names: Nimbu, Limu (Hind.); *Nimma-pandu* (Tel.).

Habitat: Generally cultivated in gardens for its fruit.

The different varieties under cultivation are the following :—

I. **Citrus medica** proper, the Citron. *Turang, Kutla* (Hind.); *Nima-pandu* (Tel.).
II. **Citrus Limonum** Risso, the Lemon. *Barra nimbu* (Hind.): *Pedda Nima-pandu* (Tel.).
III. **Citrus acida** Pers., the sour lime; *khatta nimbu, limu* (Hind.).
IV. **Citrus Limetta** Risso, the sweet Lime; *Mitha* or *sharbati nimbu* (Hind.); *sakar nimbu* (Mar.).

Uses: All the varieties are of great economic and medicinal importance.

50. **Citrus Aurantium** Linn., *F.B.I.*, I, p. 515.
(The orange.)

Vern. Names: *Narangi, Santara* (Hind.), *Narangapandu* (Tel.).

Habitat: Cultivated for its fruit in gardens throughout the Dominions especially on the Aurangabad side.

Uses: The fruits are eaten, being regarded by the *Unani* physicians as cold and dry, good for colds and coughs when febrile symptoms are present, also for biliousness and diarrhœa. The peel is useful for checking vomiting, and expelling intestinal worms, also good for removing pimples. Orange sherbet is refreshing, cooling and stimulating, taken especially in the hot season. The water distilled from the flowers, and the essence extracted in the form of oil from the rind and flowers, are also of medicinal importance.

51. **Citrus decumana** Linn., *F.B.I.*, I, p. 516.
(Pomelo.)

Vern. Names: *Chakotra* (Hind.); *Eda-pandu* (Tel.): *Batabi Libu* (Beng.).

Habitat: Cultivated in gardens all over for its fruit.

Uses: The fruit is eaten, but is not much relished. The leaves are useful in certain diseases.

52. **Aegle Marmelos** Correa., *F.B.I.*, I, p. 516.

Vern. Names: *Bael, Bael-phal* (Hind.); *Bilvapandu* (Tel.)

Habitat: Common round about the city in gardens, and in the forests. I have seen many trees growing apparently wild in Pakhal and the adjacent districts. It is also cultivated.

Uses: Root, bark, flowers, fruit and rind are of medicinal value. The tree is sacred to Hindus and is often planted near temples: its trifoliate leaves are offered to the gods. The pulp, either from the ripe fruit or obtained by roasting the green one, is extremely good for stomach complaints. *Bael-sherbat* (from ripe fruit) is very refreshing and cooling.

XVI. BURSERACEÆ.

53. **Balsamodendron Mukul** Hook, *F.B.I.*, I, p. 529.

Habitat: Common in the Aurangabad District (Marhatwari side), less common on the Telangana side.

Uses: The '*Gugal*' is used in preparing an ointment for ulcers. It is largely used by the Hindus as an incense in their temples.

54. **Boswellia serrata** Roxburgh, *F.B.I.*, I, p. 528.

Vern. Names: *Anduk*, *Salai* (Hind. and Mar.); *Anduku* (Tel.).

Habitat: Common on dry hills throughout the Dominions, in the hottest and driest exposures.

Uses: The green-gum-resin possesses an agreeable scent, and is used as an incense. An oil is distilled from the gum-resin, said to be useful in venereal complaints and is also used in making an ointment for sores.

55. **Garuga pinnata** Roxburgh, *F.B.I.*, I, p. 528.

Vern. Names: *Garuga*, *Garga*, *Garu* (Tel.).

Habitat: A wide-spread tree in the forests almost throughout the Dominions.

XVII. MELIACEÆ.

56. **Azadirachta indica** A. Juss., *F.B.I.*, I, p. 544; Cooke, *Fl. Bomb. Pres.*, Pt. II, p. 207. (The Margosa tree.)

Vern. Names: *Neem* (Hind.), *Yapa* (Tel.), *Nimbay* (Mar.).

Habitat: Very common and wild throughout the Dominions, growing in villages and on road sides; planted in compounds of houses and in gardens.

Uses: All parts of the tree are of great economic and medicinal importance. The oil extracted from the fruits is antiseptic and is recommended by the Indian physicians for sores, itches and the like. A hot decoction of the fresh leaves is much used for washing and dressing wounds. It is a very good substitute for boric powder and other disinfectants and antiseptics. 'The toddy obtained from the bark is refrigerant, nutrient and alterative tonic: the flowers are a demulcent tonic and stomachic; the gum demulcent-tonic; the oil, nuts and leaves local stimulant, insecticide and antiseptic: the root-bark, bark and young fruit tonic and antiperiodic' (Kirtikar—*Indian Medicinal Plants*). The twigs are used for cleaning the teeth; one end of the twig is crushed to make it brush-like. It is considered very healthy to sleep or rest under a *Neem* tree. It is held sacred by the Hindus who make idols of its wood. Most parts of this tree are employed in medicine.

57. **Melia azedarach** Linn., *F.B.I.*, I, p. 544. (Persian Lilac; Bead-tree; Bastard cedar.)

Habitat: Not wild, but common under cultivation throughout.

Uses: The root-bark, bark, leaves, flowers, and fruits are all used in medicine.

XVIII. CELASTRINEÆ.

58. **Gymnosporia montana** Roxburgh, *F.B.I.*, I, p. 621.

Vern. Name: *Danti-chettu* (Tel.).

Habitat: Very wild, covering miles and miles of forest.

Uses: The bark ground to a paste is applied with other oils to the head for destroying pediculi (Kirtikar, Vol. I, p. 230).

For information regarding the disintegrating action of the roots of this plant refer to Mr. Abdur Rahman Khan's notes in 'Current Science', I, p. 78 (1932), and in 'Nature', CXXXI, p. 844 (1933).

XIX. RHAMNEÆ.

59. **Ventilago madraspatana** Gærtn., *F.B.I.*, I, p. 630.

Vern. Names: *Sungur-tiga* (Tel.), *Lokhandi*; *Kanwail* (Mar.).

Habitat: Commonly found in almost all forests.

Uses: The root-bark gives a valuable red dye and it is also used in medicine locally.

60. **Zizyphus jujuba** Lamk., *F.B.I.*, I, p. 632.

Vern. Names: *Ber* (Hind.); *Regu-pandu* (Tel.): *Ber* (Mar.).

Habitat: Very wild in forest all over.

Uses: The ripe fruits are eaten. Wood is used for agricultural implements and fuel. Tassar silk-worms and lac insects feed on its leaves and branches.

61. **Zizyphus vulgaris** Lamk., *F.B.I.*, I, p. 633.

Vern. Names: *Unnab* (Arabic).

Habitat: Cultivated for its fruit.

Uses: Dried fruits are used in medicine for purifying the blood. Syrup of the dried fruits is used for cough. Bark and gum are also medicinal. During famines in certain areas the poor cultivators powder the dry fruits (together with the seeds) of the wild variety and make a kind of meal out of which they prepare bread.

XX. AMPELIDEÆ.

62. **Vitis vinifera** Linn., *F.B.I.*, I, p. 652. (The Grape Vine.)

Vern. Name: Angur-ki-bel.

Habitat: Though cultivated in gardens throughout, it is extensively grown in Aurangabad (Marhatwari side) where it produces good fruit.

Uses: The dried fruits (*Monakkai-Hind.*) are used in medicine. Grapes and raisins are attennant, suppurative and the most digestible of fruits, purifying the blood and increasing its quantity and quality (according to Mohamadan writers and Kirtikar, I, p. 345).

I have found fish manure along with cowdung, and blood to be very effective for the production of good fruit.

63. **Vitis latifolia** Roxb., *F.B.I.*, I, p. 652.

Vern. Names: Katti-bel, Pani-bel (Hind.); *Pula-tiga, Doba-tiga* (Tel.).

Habitat: A common climber in most forests throughout the Dominions.

Uses: The tender leaf-buds are curried.

XXI. SAPINDACEÆ.

64. **Sapindus laurifolius** Vahl., *F.B.I.*, I, p. 683. (Soap-Nut tree.)

Vern. Names: Ritha (Hind.); *Kukudu* (Tel.); *Arita* (Mar.).

Habitat: Not wild, but generally cultivated all over for its fruits.

Uses: The fruits (known as *Ritha*) which are sold in bazaars everywhere, are used as a substitute for soap in washing. They are also used in medicine. They are regarded by the native physicians as hot, dry, tonic and alexipharmic and useful in colic pain, diarrhœa, cholera and antidotes against reptilian venoms. The root is said to be useful as an expectorant. The pericarp of soap-nut, says Kirtikar, is one of the best, cheapest, and commonest emetics in India.

65. **Schleichera trijuga** Willd., *F.B.I.*, I, p. 681.

Vern. Names: Kusumb (Hind.); *Pusku* (Tel.); *Kun* (Mar.).

Habitat: Found in all forests, especially abundant in the Pakhal Reserve, and the nearby forests.

Uses: The bark is astringent; rubbed up with oil, the natives use it to cure itch (Roxburgh). The oil of the seeds is

good for the scalp and promotes the growth of the hair. It is also used as a cure for itch.

66. **Dodonæa viscosa** Linn., *F.B.I.*, I, p. 697.

Vern. Names: Jangli-anar (Hind.); *Puli-vailu* (Tel.).

Habitat: A very common shrub in all forests throughout Hyderabad.

Uses: Being of quick growth it makes an excellent hedge. The leaves are used in baths and fomentations (Lindley). The powdered leaves when applied to wounds heal them without leaving any scars. Also applied to burns and scalds. In the Punjab, the bruised leaves are used in snake-bite; also given internally.

XXII. ANACARDIACEÆ.

67. **Mangifera indica** Linn., *F.B.I.*, II, p. 13. (Mango tree).

Vern. Names: Am (Urdu); *Ām* (Hind.); *Amba* (Persian); *Mamadi* (Tel.).

Habitat: Found throughout the Dominions, grown in gardens in groves.

Many varieties propagated by means of layers and graftings yield better fruits than those grown from seed. Several cultivated varieties are known in India, the best local variety is the one known as 'Mulgoba', next come 'Neelum', 'Alfan,' and others.

Uses: Green and unripe fruits are cut into small bits and pickled; ripe fruits are delicious and laxative A delicious sherbet is made of the roasted unripe or half-ripe fruits with water and sugar. Ripe fruits are preserved as well. Sometimes the green bits are boiled with sugar syrup and spices so as to make what is known as the 'mango chutney'. Mango juice is also dried in the form of thin cakes called '*Amwaat*' or '*Amras*'.

68. **Semecarpus anacardium** Linn., *F.B.I.*, II, p. 30. (Marking-nut tree.)

Vern. Names: Bhilava (Urdu); *Bheluа* (Hind.); *Bibua* (Tel.),

Habitat: Very common in forests throughout the Dominions.

Uses: The thick black pericarp of the fruit contains the corrosive juice which is used by the *Dhobies* (washermen) for marking clothes. The yellow, astringent hypocarp (commonly known as *Bhilava ka phool*) is usually eaten. The oil of the seed is applied externally for several pains and sores, also used internally with milk in relaxation of uvula and cough, especially in children. Very useful in all forms of neuritis. Oil mixed

with butter or ghee is very efficacious in scaly skin eruptions. There are far too many useful properties of this drug to be mentioned here.

69. **Anacardium occidentale** Linn., *F.B.I.*, II, p. 20. (Cashew-nut tree.)

Vern. Names: *Kaju* (Urdu) : *Jidi mamadi* (Tel.).

Habitat: Native of America and West Indies. Does not flourish here.

Uses: The enlarged peduncle and the seeds (really fruits), popularly sold in the market as *Kaju* fruits, are eaten. Seed and bark are of medicinal importance. The bark is said to have alterative properties. The tar which contains about 90% of anacardic acid and 10% of cardol, has recently been recommended as an external application in leprosy, ringworm, corus, and obstinate ulcers (Kirtikar). The spirit distilled from the expressed juice of the fruit may be used as a stimulant (Watt). The kernel is nutritive, demulcent, and emollient; and the oil emollient, and a mechanical as well as a chemical antidote for irritant poisons. It is also a good vehicle of liniments and other external applications (Mooden Sheriff)

XXIII. MORINGEÆ.

70. **Moringa pterygosperma** Gærtn., *F.B.I.*, II, p. 45. (Drum-stick plant; horse-radish tree.)

Vern. Names: *Soazna* (Hind.); *Soajna* (Beng.); *Munga*, *Morunga* (Tel.); *Mungai*, *Sainga*, *Saigal* (Mar.).

Habitat: Very common in cultivation throughout the Dominions.

Uses: The fruit, flowers, and leaves are made into a curry. 'The root is pungent, acrid, stimulant, and diuretic and is applied externally as a rubefacient.' (Kirtikar, *Indian Med. Plants*, I, p. 397.) The seed is given in connection with the disorders due to the enlargement of liver and spleen. A poultice made with the root reduces swellings and blisters. The oil of the seeds is, in some places, used for rheumatic pains. The charcoal of the wood is used in fireworks.

XXIV. LEGUMINOSÆ.

71. **Crotalaria retusa** Linn., *F.B.I.*, II, p. 75.

Vern. Name: *Ghagri*.

Habitat: Quite common all over, especially on the Marhatwgri side in waste lands and forests, growing in sandy soil.

72. **Crotalaria sericea** Retz., *F.B.I.*, II, p. 75.

Habitat: Same as of the preceding species.

Both the above species, according to F. A. Partridge (*Forest Flora of Hyderabad*), yield a fairly strong fibre which makes good cordage.

73. **Crotalaria laburnifolia** Linn., *F.B.I.*, II, p. 84; Cooke, *Fl. Bomb. Pres.*, pt. II, p. 304.

Habitat: It is a common species throughout the Dominions.

Uses: The root is said to be an antidote for snake-poison (local information).

74. **Butea frondosa** Roxb., *F.B.I.*, II, p. 194 (The 'Forest Flame'.)

Vern. Names: *Palas* (Hind.), *Palas* (Tel.) *Modugu* (Mar.)

Habitat: A very common forest tree of Hyderabad.

Uses: A dye made from the petals was formerly much used by the Hindus in their 'Holi' festival, but now it is substituted by aniline dyes. The leaves are largely used by the poor as food-platters. Root-bark affords a strong rope-fibre. The red exudation makes the gum-kinos of commerce. It is sold in the bazaars as a medicine. Dr. Waring (*Bazaar Medicines*, p. 31) says: 'It is an excellent astringent, similar to catechu, but being mild in operation it is better adopted for children and delicate females. The dose of the powdered gum is 10 to 30 grains, with a few grains of cinnamon'. The addition of a little opium increases its efficacy. It is also used for precipitating indigo. The seeds are used as a purgative and vermifuge. The flowers are astringent, depurative, diuretic, and aphrodisiac. The leaves are astringent, tonic, and aphrodisiac; are used to disperse boils and pimples, and are given internally in flatulent colic, worms, and piles (Makhzan-ul-Adwiya, *cf.* Kirtikar, *Medicinal Plants*). The branches harbour lac insects.

75. **Trigonella Fœnum-græcum** Linn., *F.B.I.*, II, p. 87. (Fenugreek.)

Vern. Names: *Methi* (Hind.), *Mentulu* (Tel.).

Habitat: Cultivated very extensively throughout Hyderabad.

Uses: The leaves and seeds are used in curries. The seeds are also considered carminative, aphrodisiac, and tonic. They are useful in rheumatism, loss of appetite, dropsy, chronic cough, and enlargements of the spleen and liver. The leaves possess cooling properties, a poultice of them is used for swellings and burns.

83. **Phaseolus vulgaris** Linn., *F.B.I.*, II, p. 200.
(French Bean or Kidney Bean.)

Vern. Name: *Lobha*, or *Loba* (Hind.).

Habitat: Cultivated throughout Hyderabad for its pods, but in less abundance than *Dolichos lablab*.

Use: The young pods are curried.

84. **Phaseolus radiatus** Linn., *F.B.I.*, II, p. 203.

Vern. Names: *Urud*, *Mash* (Hind.).

Habitat: Cultivated especially on the Marhatwari side.

Uses: This is, perhaps, the most highly valued of all the *Phaseolus* pulses. The seeds are indeed very nutritious and fattening. They are also given to cattle and horses. The straw is considered to be an excellent fodder. ' The seed is the reputed origin of the weight known as masha, twelve of which go the tola, 480 to one pound ' (Duthie). The seeds are used medicinally in paralysis, rheumatism and affections of the nervous system, fever, piles, affections of the liver, and cough (Kirtikar).

85. **Phaseolus Mungo** Linn., *F.B.I.*, II, p. 203.

Vern. Name: *Mung* (Hind.).

Habitat: Very extensively cultivated all over.

Uses: The pulse is eaten in the form of ' Dal ' (a curry to which usually no meat is added), or cooked with rice (*Khichri*). The native physicians consider it cool, light and astringent. It is used to strengthen the eyes (Watt).

86. **Cajanus indicus** DC., *F.B.I.*, II, p. 217.

Vern. Names: *Tuvar*, *Arhar* (Hind. and Mar.); *Kandulu* (Tel.).

Habitat: Cultivated extensively for its seeds.

Uses: The branches and leaves are given to cattle as fodder. The seeds are made into a curry ' Dal ' or cooked with rice (*Khichri*).

87. **Dalbergia latifolia** Roxb., *F.B.I.*, II, p. 231.
(Rose Wood.)

Vern. Names: *Shisham* (Hind. and Mar.); *Jit-eggi* (Tel.); *Sissu* (Mar.).

Habitat: Found almost throughout the Hyderabad forests, especially abundant in the Pakhal, Mahadeopur, and Amrabad Reserves.

Uses: The wood, which is extremely hard and close-grained, is employed for cabinet work. It takes on very good polish ; also used for carving turnery and ornamental work.

88. **Dalbergia Sissoo** Roxb., *F B.I.*, II, p. 231.

Vern. Names: *Sisso* (Hind.) ; *Sisvi* (Mar.).

Habitat: Planted in station-yards, on roadsides, etc.

Uses: The wood is very hard, close-grained, and very durable. It is employed for furniture, etc.

Other species of the genus recorded by E. A. Partridge (*Forest Flora of Hyderabad, Deccan*) are :—

89. **Dalbergia lanceolaria** Linn., *F.B.I.*, II, p. 235.

Vern. Names: *Pasarganni* (Tel) ; *Dandus* (Mar.).

Habitat: Not very common, but frequently met with in the Hyderabad forests.

90 **Dalbergia paniculata** Roxb., *F.B I.*, II, p. 236.

Vern. Name: *Sopara* (Tel.).

Habitat: A very common tree in the Telangana forests.

91. **Dalbergia volubilis** Roxb., *F.B.I.*, II, p. 235.

Vern. Names: *Gumidi-tiga, Gamlap-tiga* (Tel.).

92. **Pongamia glabra** Vent., *F.B.I.*, II, p. 240.

Vern. Names: *Karanj* (Hind. and Mar.); *Kangu* (Tel.).

Habitat: Found wild in all the Hyderabad forests, also planted in avenues and gardens.

Uses: The wood makes a good fuel. The juice of the leaves is used for washing ulcers The seeds are useful as an external application in skin diseases. The fresh bark is used internally in bleeding piles A decoction of the leaves is used for fomentations in rheumatic pains (S. Arjun, *cf.* Kirtikar, I, p. 460). The oil of the seeds is useful in cutaneous affections.

93. **Arachis hypogæa** Linn., *Cooke, Fl. Bomb. Pres.*, pt. II, p. 408.

Vern. Names: *Mung-phalli* ; *Vilayati mung* (Hind.); *Bilati mung* (Beng.) ; *Bhui-mung* (Mar.) ; *Nila-sanagalu* (Tel.).

Habitat: Cultivated throughout for its seeds.

Uses: Plain, roasted, and fried nuts are eaten. The seeds or nuts yield an oil resembling olive-oil, for which it is used as a substitute. 'The unripe nuts are sweet and are given to women whose supply of milk is insufficient for their children; the unripe nuts are less oily and, therefore, more easily digested' (Subba Rao, *cf.* Kirtikar, I, p. 426). They are said to produce excess of bile if eaten in a big quantity.

94. **Cicer arietinum** Linn., *F.B.I.*, II, p. 176. (The Gram or Chick-pea.)

Vern. Names: *Chana, bût* (Hind.); *Chhola* (Beng.); *Changel, Senagaloo* (Tel.).

Habitat: Widely cultivated throughout the Dominions.

Uses: The unripe green grams '*bût*' are eaten plain. Grams constitute the chief nourishing food of horses in Hyderabad. They are soaked in water overnight, and given in the morning, and soaked likewise from morning till evening for the evening feed. The stalks and leaves, after the seeds are removed, constitute a valuable fodder for cattle who eat them greedily. The plant while growing, exudes an acidic liquid, which is obtained by collecting the dew from the foliage. It makes a very good vinegar which is astringent and digestive. Roughly ground grams are made into 'dal' and other curries. They are also largely used in many preparations of sweets.

95. **Lens esculenta** Mœnch., *F.B.I.*, II, p. 179. (The Lentil.)

Vern. Name: *Masur* (Hind.).

Habitat: Cultivated all over for its seeds.

Uses: Lentils are considered to be one of the most nutritious pulses. They are prepared as 'dal'; also cooked with rice. The tender pods are eaten as vegetable, and the leaves and stalks serve as fodder for cattle.

96. **Pisum sativum** Linn., *F.B.I.*, II, p. 181.

Vern. Name: *Matar* (Hind.).

Habitat: Cultivated all over as a cold-weather crop. Thrives best in black rich soil (Marhatwari side).

Uses: The seeds are eaten plain, as well as curried.

97. **Cæsalpinia pulcherrima** Swartz., *F.B.I.*, II, p. 255.

Vern. Names: *Gul-tora, Torai* (Hind.); *Peyditangedu* (Tel.).

Habitat: Found almost throughout the Dominions in waste places, gardens and fields. Flowers throughout the year.

Uses: Leaves, flowers and seeds are used in medicine (Watt).

98. **Cæsalpinia Bonducella** Fleming, *F.B.I.*, II, p. 254.

Vern. Names: Gajga, Gachka (Hind.); *Gatchi-kai* (Tel.).

Habitat: All over Hyderabad, near villages in hedges and bushes.

Uses: The seeds are used in Hyderabad as well as throughout India for various fevers.

99. **Poinciana regia** Boger., *Cooke, Fl. Bomb. Pres.*, pt. III, p. 415. (The gold-mohur tree.)

Vern. Names: Gul-mohr (Hind.); *Sima-sankesula* (Tel.).

Habitat: Although originally a native of Madagascar it has become a native of Hyderabad also. Very common throughout the Dominions, planted on roadside and in gardens.

100. **Poinciana elata** Linn., *F.B.I.*, II, p. 260.

Vern. Names: Sankesar (Hind.); *Sankesula* (Tel.).

Habitat: Common round about the city of Hyderabad, also on the Telangana, less common on the Marhatwari side.

Uses: The yellowish white wood is often utilized for toys and other small articles.

101. **Parkinsonia aculeata** Linn., *F.B.I.*, II, p. 260.

Vern. Names: Vilayati kikar (Hind.); *Sima-tuma* (Tel.); *Adanti* (Mar.).

Habitat: Common throughout Hyderabad. Abundant on the Telangana side.

Uses: The wood makes a good fuel. A useful fibre is also obtained from the bark.

102. **Cassia Fistula** Linn., *F.B.I.*, II, p. 261. (Purging Cassia or the Indian Laburnum.)

Vern. Names: Amaltas (Hind.); *Riala* (Tel.); *Gurmala* (Mar.).

Habitat: Found in abundance in forests throughout the Dominions.

Uses: The whole plant is purgative. The pulp, root-bark, leaves, and flowers are used in medicine. The pulp is

also used in making a native tobacco mixture 'Godakhu' meant for 'hubble-bubbles'. The bark is also largely used for tanning. The root is described as a laxative, useful in fever, heart-disease, biliousness, etc. The juice of the young leaves is an antidote for the irritation caused by the application of the marking-nut juice.

103. **Cassia auriculata** Linn., *F.B.I.*, II, p. 263.
(The Tanner's Cassia.)

Vern. Names: *Tarwar* (Hind.); *Tangedu* (Tel.).

Habitat: *Tarwar* is extremely common and wild throughout the Dominions. It is grown in the country side along roads, in fields, amongst hedges, etc.

Uses: The bark is used for tanning. The petals when cooked with eggs in a curried form are rather tasty. Bark, leaves, flowers and seeds are used in native medicine, and are astringent. According to Trimen, the leaves are used in Ceylon as a substitute for tea. The powder of dry seeds is used as a valuable external remedy in certain stages of opthalmia.

104. **Cassia siamea** Lam., *F.B.I.*, II, p. 264.

Vern. Name: *Niala-Tangedu* (Tel.).

Habitat: Native of Ceylon. Commonly planted in avenues along roadsides round about Hyderabad City and Secunderabad (E. A. Partridge, *Forest Flora of Hyderabad*).

105. **Cassia Absus** Linn., *F.B.I.*, II, p. 265.

Vern. Name: *Chaksu* (Hind.).

Habitat: A common roadside weed.

Use: The seeds are used for sore eyes locally.

106. **Cassia tora** Linn., *F.B.I.*, II, p. 263.

Vern. Name: *Chakunda.*

Uses: The angular seeds *Kuari* are used in tanning, and a blue dye is also prepared from them.

107. **Hardwickia binata** Roxb., *F.B.I.*, II, p. 270.

Vern. Name: *Anjan* (Hind.); *Yeppa* (Tel.); *Kattu-dugi* (Mar.).

Habitat: Abundant in the Pakhal Reserve and the nearby forests, also on the Marhatwari side.

Uses: The wood is used for making agricultural implements, house posts, and various other articles.

108. **Saraca indica** Linn., *F.B.I.*, II, p. 270.

Vern. Name: Ashok.

Habitat: Grown in the vicinity of temples, common in villages.

Uses: The bark is used by Hindu physicians in uterine affections. Flowers pounded and mixed with water are used in hæmorrhagic dysentery (Watt) It is worshipped by the Hindus.

109. **Tamarindus indica** Linn, *F.B.I.*, II, p. 273. (Tamarind.)

Vern. Names: Imli, Amli (Hind.); *Chinta* (Tel); *Chitz* (Mar.).

Habitat: Very common all over, especially round about the city and on the Telangana side, grown on roadsides, in villages.

Uses: The pulp of the pod is almost indispensible for the preparation of most of the acid curries, owing to the presence of a large amount of tartaric acid. It is also greatly taken as an antidote for the excess of bile. It is a laxative. The soft young leaves (*chugar*), less commonly the flower-buds, are used in curries. The roasted seeds are eaten by the poor in case of famine. The wood is a good fuel, also used for the internal fitting of ordinary houses or cottages. The ripe fruit is regarded as a laxative, refrigerant, digestive and carminative. A poultice of the leaves or the pulp of the ripe fruit is applied to inflammatory swellings. The juice of the flowers taken internally is useful for bleeding piles. The bark is considered to have astringent and tonic properties (Dymock).

110. **Bauhinia tomentosa** Linn., *F.B.I.*, II, p. 275.

Vern. Names: Kachnar (Hind.); *Kanchani* (Tel.).

Habitat: Cultivated in several parts of the Dominions.

Uses: The flower-buds are used in curries, also in native medicine locally. The bark, fruit, and seeds are used in medicine at several places in the south, infusion of the bark as an astringent gargle; paste of seeds for external application to wounds

111. **Bauhinia variegata** Linn., *F.B.I.*, II, p. 284.

Vern. Name: Kachnar (Hind.).

Habitat: Like the previous species it is extensively cultivated in the Dominions.

Uses: Leaves and flower-buds are used in curries. The bark and roots are medicinal. A gargle is made from the bark,

and is useful in sore-throat. A decoction of the root is given in dyspepsia.

112. **Bauhinia purpurea** Linn., *F.B.I.*, II, p. 284.

Vern. Names: Pedda-ari, Bodanta-chettu, Devakasia (Tel.); *Kanchan* (Mar.).

Habitat: Found in all the forests throughout the Dominions, also cultivated in gardens.

Uses: The bark, root, and flowers are used in medicine as a maturant for boils and abscesses (T. N. Mukerji). Decoction of the bark used as a wash for ulcers. The wood, which is durable and hard enough, is used for agricultural implements. The bark is used in tanning. Locally, the flower-buds are eaten either cooked or in a pickled form.

113. **Bauhinia acuminata** Linn., *F.B.I.*, II, p. 276.
(White Bauhinia.)

Vern. Name: Kachnar (Hind.).
This name is given to three species of *Bauhinia*, *i.e. variegata, tomentosa*, and *acuminata*.

Habitat: Commonly cultivated near villages.

Use: The flower-buds are curried.

LEGUMINOSÆ (Mimosoideæ).

114. **Mimosa pudica** Linn., *F.B.I.*, II, p. 291.
(Sensitive plant.)

Vern. Names: Lajwanti, Choi-Moi, Sharmindi (Hind.).

Habitat: Generally grown in pots in houses and gardens all over.

Uses: The root and leaves are used in medicine. The juice is useful in diseases arising from corrupted blood and bile (Mr. Mohammad Husain, the 'Makhzan'). It is also applied externally to fistular sores (Dymock). Root and leaves used in piles and fistula.

115. **Acacia arabica** Willd., *F.B.I.*, II, p. 293.
(Indian Gum-Arabic tree.)

Vern. Names: Babul, Kikar (Hind.); *Nalla tuma* (Tel.).

Habitat: Very common and abundant throughout the Dominions. On the Marhatwari side, Aurangabad, Jalna, Parbhani, etc. and also in the Bidar, Raichur, Bhir and Gulbarga districts this is the only natural tree—growth for miles and miles of black soil.

Uses: The pods are a food of cattle, especially the goats. The wood is utilized for making agricultural implements, carts, door-frames, etc. and is used as fuel. The thorny branches are used for fencing. The bark and leaves are given in diarrhœa as astringents. The decoction of the bark mixed with other medicines is applied externally to ulcers. The gum is useful in dyeing and cloth-printing, and is also used in medicine, being considered by native physicians as useful in diabetes. Its common use as an adhesive is well known.

116. **Acacia concinna** DC., *F.B.I.*, II, p. 296.

Vern. Names: Sike-kai (Hind. and Tel.); *Ban-Ritha* (Hind.); *Gogu* (Tel.).

Habitat: Wild on the Aurangabad Ghats. Generally cultivated all over for its leaves and fruit.

Uses: The pods are used like soap-nut for washing the hair. The leaves and pods are commonly used in medicine by the native physicians in cases of jaundice and other biliary troubles.

Other Acacias recorded by E. A. Partridge (*Forest Flora of Hyderabad, Deccan*) from the Dominions are :—

117. **Acacia leucophlea** Willd., *F.B.I.*, II, p. 294.

Vern. Names: Safed kikar or *Safed babul* (Hind.); *Tella-tuma* (Tel.); *Hewar* (Mar.).

Habitat: Found in dry forests all over.

Use: The bark has properties similar to that of *Acacia arabica.*

118. **Acacia catechu** Willd., *F.B.I.*, II, p. 295.

Vern. Names: Khair (Hind. and Mar.); *Kaththa* (Hind.); *Sundra*, *Podali-manu* (Tel.).

Habitat: It is met with in some forests, but the growth is stunted; it never attains the average size of the tree as found in Northern India.

Uses: I have not heard of *Catechu* or *Kaththa* having ever been extracted here. It is imported from Northern India to be used with betel leaves or *pan*. The wood is utilized in making agricultural implements, etc. *Catechu* and leaves are of medicinal importance, the former used in combination with other astringent drugs in diarrhœa and dysentery, also used in the form of injection for gonorrhœa. The gum in combination with some medicines is efficaceous in pulmonary affections, diarrhœa and genito-urinary troubles.

119. **Pithecolobium dulce** Benth, *F.B.I.*, II, p. 302.

Vern. Names: Gorak-imli, Lāl-imli.

Habitat: A native of Mexico, introduced into the Philippine Islands and thence into India. It is met with in Hyderabad growing in the compounds of spaceous houses, in gardens and as a hedge plant.

Uses: The wood is chiefly used for fuel. The pulp is eaten.

120. **Parkia biglandulosa** Wight and Arn., *F.B.I.*, II, p. 289.

Vern. Name: Ood-ka-jhar.

Habitat: A native of Afiica (Cooke) and Malay Peninsula (Roxburgh). Only a few trees are found growing in the compounds of houses round about Hyderabad City.

121. **Albizzia Lebbek** Benth., *F.B.I.*, II, p. 298.

Vern. Names: *Siras*, *Siris*, *Shirash* (Hind.); *Shirish* (Sans.); *Dirasan* (Tel.); *Chichola*, *Mothasiras* (Mar.).

Habitat: Throughout the Dominions. Often planted as a roadside tree. Distribution through India, Malay Isles, China, N. Australia, Tropical Africa.

Uses: The gum is used under the name of '*lera*' as an adulterant for pure gum arabic in calico-printing and in the preparation of gold and silver leaf cloths (Baden Powell, *cf.* Watt, *Dict. Econ. Prod.*, I, p. 157). The bark is used in tanning leather. The oil from the seeds is considered useful in Leprosy. The seeds are officinal and form part of an *anjan* used for ophthalmic diseases (Stewart). The bark is applied to injuries to the eye (Madden). The bark and seeds are astringent, given in piles, diarrhœa, etc. The powder of the root-bark is said to strengthen spongy and ulcerated gums. The flowers are considered a cooling medicine and are externally applied to boils, eruptions, swellings, etc. They are regarded as an antidote to poisons. The leaves are a good fodder for cattle. The wood makes a good fuel and is used in making furniture, boats, houseposts, etc. (For further information see Watt, *Dict. Econ. Prod.*, I; Chopra, *Ind. Drug.* I; Kirtikar, *Ind. Med. Pl.*)

XXV. ROSACEÆ.

122. **Rosa damascena** Mill., *F.B.I.*. II, p. 364.

Vern. Name: *Gulab* (Hind.).

Habitat: Extensively cultivated in gardens for its flowers throughout Hyderabad.

Uses: The sweet-scented flowers are used in making garlands which it is customary to wear in all Indian ceremonies. Roses along with jasmines and other flowers are used by the Hindus in their religious ceremonies. Those, who bury their dead, viz. the Muslims and the Christians, put roses on the graves of the dead. Rose-water and rose-perfume (*Gulab-ka-itr*) are extracted from roses. The former is used in many sweets.

Flower-buds instead of petals are preferred by physicians because they are more astringent. They are considered cardiacal and tonic. A preparation of petals and white sugar *Gulkand* is cooling, tonic and fattening. Rose-water is used in many ointments.

XXVI. CRASSULACEÆ.

123. **Bryophyllum calycinum** Salisb., *F.B.I.*, II, p. 413.

Vern. Name: *Zakhm-i-hyat* (Hind.).

Habitat: Often much cultivated in gardens throughout Hyderabad.

Uses: Crushed leaves are applied to wounds, burns, boils, cuts and bruises with advantage.

XXVII. COMBRETACEÆ.

124. **Quisqualis indica** Linn., *F.B.I.*, II, p. 459. (The Rangoon creeper.)

Habitat: Grown in gardens.

Uses: The seeds are supposed to be anthelmintic.

125. **Terminalia Catappa** Linn., *F.B.I.*, II, p. 444. (The Indian Almond tree.)

Vern. Name: *Jangli-badam* (Hind.).

Habitat: An ornamental tree commonly planted throughout the Dominions in gardens and avenues.

Uses: The juice of the leaves and the milk of the nuts are of medicinal importance. The oil from the kernels may be used as a substitute for almond. The bark is said to be an astringent. The juice of the young leaves is utilized in the preparation of an ointment for leprosy, scabies and other cutaneous diseases. Taken internally it is believed to be useful for headache and colic (Lisboa).

126. **Terminalia tomentosa** Wight and Arn. Prodr., *F.B.I.*, II, p. 447.

Vern. Names: *Asan* (Hind.); *Maddi* (Tel.); *Sadada*, *Saj* (Mar.).

Habitat: Very common in the forests throughout the Dominions.

Uses: *The gum is used as an incense and cosmetic.* The bark is occasionally used as a dye which is brown or buff and is chiefly used in tanning.

A decoction of the bark is said to be used internally for atonic diarrhœa, etc.; and locally as an application to callous ulcers. The lac insect is sometimes found on the branches.

Tasar silkworms feed on the leaves.

The wood makes an excellent fuel. It is largely used for building agricultural implements, furniture, etc. (Watt, *Dict. Econ. Prod. Ind.*, VI, pt. IV, p. 37).

XXVIII. MYRTACEÆ.

127. **Psidium guyava** Linn., *F.B.I.*, II, p. 468.
(Guava tree.)

Vern. Names: *Jam*, *Amrood* (Hind.); *Jama Kaya*, *Jama-pandu* (Tel.).

Habitat: Very commonly cultivated all over the Dominions, especially on the Marhatwari side. Occasionally found semi-wild.

Uses: Fruit very much relished, either eaten plain or stewed in sugar, also made into a delicious jelly and cheese. The bark is astringent and is useful in diarrhœa. The decoction of the leaves is to some extent useful in cholera, in arresting vomiting and diarrhœa (*Pharm. Ind.*).

128. **Eugenia jambolana** Lamk., *F.B.I.*, II, p. 499.

Vern. Names: *Jamun* (Hind.); *Neredu*, *Jinna* (Tel.); *Jambul* (Mar.).

Habitat: Very widespread in forests throughout the Dominions. Also planted for its fruit.

Uses: Considered sacred by the Hindus who plant it near their temples. Fruit edible. Bark used as a good, brown dye. The semi-fermented juice of *jamun* (*jamun-ka-urkh*) or *sirka* is very good for stomach-ache. The bark is astringent, its fresh juice being given with goat's milk in the diarrhœa of children. The expressed juice of the leaves is given in dysentery (Dutt). The root, fruit and seeds are useful astringents. Recently the seeds have been used in diabetes (Kirtikar).

129. **Barringtonia acutangula** Gærtn., *F.B.I.*, II, p. 508.

Vern. Names: *Hijjul*, *Sarmandar-phal* (Hind.); *Kadami* (Tel.); *Tiwar* (Mar.).

Habitat: Common in most of the forests near streams and on the embankments of tanks.

Uses: The root is bitter and possesses properties similar to cinchona, cooling and aperient (Kirtikar). The seeds are very warm and dry, prescribed in colds, used in powdered form as snuff in headache (Dutt). They are also used as an aromatic in colic and in ophthalmia (Watt).

130. **Eugenia jambos** Linn., *F.B.I.*, II, p. 474.
(The Rose apple.)

Vern. Name: *Gulab-Jamun* (Hind.).

Habitat: Cultivated in gardens for its fruit.

131. **Eugenia Heyneana** Wall., *F.B.I.*, II, p. 500.

Vern. Names: *Pan-Jambul* (Mar.); *Chinna-neredu* (Tel.).

Habitat: Found in the beds of rivers on the Marhatwari side.

132. **Careya arborea** Roxb., *F.B.I.*, II, p. 511.

Vern. Names: *Kamba* (Hind.); *Wai-kumbha* (Mar.); *Buda-durmi* (Tl.).

Habitat: Found throughout the Dominions in forests.

Uses: The bark as well as the fruit is astringent. Flowers are demulcent, being used in colds and coughs.

133. **Myrtus communis** Linn., Cooke, *Fl. Bomb. Pres.*, Part III, p. 498.

Vern. Names: *Vilayati mehndi*, *Murad* (Hind.).

Uses: The essential oil of the leaves is useful in rheumatism. The fruit is given in diarrhœa, dysentery, rheumatism, etc.

134. **Eucalyptus globulus** Labill, Watt, *Dict. Econ. Prod. Ind.*, p. 280.

Habitat: Grown in a few gardens.

135. **Melaleuca leucadendron** Linn., *F.B.I.*, II, p. 465.
(Cardimum.)

Vern. Names: *Ilaichi* (Hind.); *Cajuputa* (Mar.).

Habitat: Grown in a few gardens as an experiment, but does not thrive well in the State.

Uses: The seeds are usually eaten with betel-leaf. The oil of the seeds is a stimulant and diaphoretic (Gamble). It is also regarded as a powerful sudorific (Watt).

XXIX. LYTHRACEÆ.

136. **Lawsonia alba** Lamk., *F.B.I.*, II, p. 573.

Vern. Names: *Mehndi* (Hind.); *Hena* (Pers.); *Maida-aku* (Tel.).

Habitat: Commonly cultivated as a hedge-plant throughout the Dominions. Often running wild.

Uses: The leaves are pounded and made into a paste, and applied by women to the nails and fingers and also along their feet colouring them beautiful crimson-red to orange-red. It is known as the *hena* dye—usually a part of the toilet even among the rich people. Paste of fresh leaves with vinegar is applied to the soles of the feet for the relief of burning pain. The paste mixed with different substances is used for various affections. The bark and flowers are also utilized for medicinal purposes, the former being given in jaundice and enlargement of the spleen, etc. the latter in headache, and as an application to bruises.

137. **Punica Granatum** Linn., *F.B.I.*, II, p. 581.
(The pomegranate.)

Vern. Name: *Anar* (Hind.).

Habitat: Cultivated all over the Dominions.

Uses: The fruit is eaten. Fresh juice of the fruits is cooling and refrigerant and prescribed by the Indian physicians. Locally the bark is used to destroy the intestinal worms. The root-bark, flowers, rind of the fruit, seeds are all of medicinal importance. The rind of the fruit and flowers are used as a bowel astringent in diarrhœa. The seeds are considered to be stomachic.

138. **Woodfordia floribunda** Salisb., *F.B.I.*, II, p. 572.

Vern. Names: *Dhan-phal, Pagadam, Jaji* (Tel.); *Dhaiti* (Mar.).

Habitat: Very common in all forests in the Hyderabad Dominions.

Uses: Flowers and leaves are of medicinal importance, the flowers being stimulant and astringent (Kirtikar).

139. **Lagerstrœmia parviflora** Roxb., *F.B.I.*, II, p. 575.

Vern. Names: *Chinangi* (Tel.); *Wundi-mana* (Mar.).

Habitat: Common in forests almost throughout the State

140. **Lagerstrœmia indica** Linn., *F.B.I.*, II, p. 575.
(The Bonnet-flower.)

Vern. Name: *China-bux* (Hind.).

Habitat: Cultivated in gardens for its handsome flowers. Indigenous to China, hence the name *China-box*.

XXX. PASSIFLORACEÆ.

141. **Passiflora fœtida** Linn., *F.B.I.*, II, p. 599.

Vern. Name: *Jhoomko lota* (Beng.).

Habitat: A native of tropical America. Frequently found in gardens.

142. **Carica Papaya** Linn., *F.B.I.*, II, p. 599.

Vern. Names: *Papai, Papita, Papiya* (Hind.); *Bappayi* (Tel.).

Habitat: Cultivated extensively all over the Dominions, especially towards the Telangana side, and Aurangabad and its Talukas on the Marhatwari side.

Uses: Fruit when ripe, is delicious and is very much relished. Locally, the skin or testa of raw fruit is pounded and applied to raw meat to make it tender The milky juice is also given internally for enlarged spleen, for ring-worm and many other diseases. The seeds also are said to be of medicinal value. The leaves contain an alkaloid, carpaine, which has been used as a heart tonic and febrifuge A very nice kind of jelly is also prepared with sugar and thin slices of this fruit. The fruit and jelly are often prescribed by the local physicians for indigestion and other ailments of the stomach.

XXXI CUCURBITACEÆ.

143. **Lagenaria vulgaris** Seringe, *F.B.I.*, II, p. 613.

Vern. Names: *Kaddu, Lauki* (Hind.); *Anapa-kai* (Tel.); *Dudhi* (Mar.).

Habitat. Very commonly cultivated throughout the Hyderabad during the rainy season.

Uses: The raw fruit is used as a vegetable. Sweet known as *Kaddu ka mithāi* is also made with it. The pulp of the fruit is considered refrigerant, diuretic and antibilious Sometimes it is applied to the soles in 'burning of the feet'. The pulp, especially of the bitter variety, is a purgative.

144. **Luffa ægyptiaca** Mill., *F.B.I.*, II, p. 614.

Vern. Name: *Ghiya-turai* (Hind.).

Habitat: Often cultivated throughout Hyderabad for its fruit during the rainy season.

Uses : The fruit is curried. The seeds are said to be emetic and cathartic.

145. **Luffa acutangula** Roxb., *F.B.I.*, II, p. 615.

Vern. Names : Turai (Hind.) ; *Beerkai* (Tel.) ; *Shirola* (Mar.).

Habitat : Extensively cultivated all over Hyderabad for its fruit.

Uses : The fruit is curried. The seeds possess purgative and emetic properties (Kirtikar, Vol. I, p. 586). The leaves are also medicinal.

146. **Momordica Charantia** Linn., *F.B.I.*, II, p. 616.

Vern. Names : Karela (Hind.) ; *Kakara-chettu* (Tel.).

Habitat : Very widely cultivated all over Hyderabad for its fruit.

Uses : The fruit is curried and the curry is supposed to be good for stomach and blood. The fruit is tonic and stomachic, and is useful in rheumatism, diseases of the spleen and liver. (*Makhzan*, *cf*. Kirtikar.) The fruit and leaves are anthelmintic, being useful in piles, leprosy, etc. The root is astringent.

147. **Benincasa cerifera** Savi., *F.B.I.*, II, p. 616. (White pumpkin ; white gourd-melon.)

Vern. Names : Petha, Gol-kaddu (Hind.) ; *Pendli-gummadi-kaya* (Tel.).

Habitat : Cultivated throughout the State, but not extensively.

Uses : The fruit is eaten as a vegetable and also used in making sweets *Pethe-ki-mithāi ; pethe-ka-hulva.*

It is popularly known as an antimercurial. It is cooling, tonic, nutritive and diuretic. It is useful in insanity and other nervous diseases, viz. pulmonary tuberculosis. *Pethe-ki-mithāi*, i.e. preserved fruit is given in piles, dyspepsia, consumption and diabetes.

148. **Cucumis Melo** Linn., *F.B.I.*, II, p. 620. (The Melon.)

Vern. Names : Khurbuza (Hind.) ; *Mulam-pandu* (Tel.).

Habitat : Extensively cultivated throughout Hyderabad, especially on the Marhatwari side. It thrives well in sandy soil, viz. on the sides of rivers, etc.

Uses : The fruit is very much relished. It is considered cool and astringent and is given in dyspepsia. The seeds are

also eaten. They are nutritive and diuretic. The oil of the seeds is also very nourishing. The root possesses emetic and purgative properties.

149. **Cucumis sativus** Linn., *F.B.I.*, II, p. 620. (Cucumber.)

Vern. Name: *Khīrā* (Hind.).

Habitat: Cultivated all over for its fruit.

Uses: When in season the fruit forms a very refreshing and nourishing food of the poor. The fruit and seeds are cooling. The latter are also diuretic.

150. **Cucumis Momordica** Roxb., Foxb., *Fl .Ind.*, III, p. 720.

Vern. Name: *Phut-kakri* (Hind.).

Habitat: Cultivated all over. One form is cultivated during the hot season and the other is a rainy season crop.

Uses: The ripe fruit is relished, but is much inferior to melon. The fruit and seeds are cooling.

151. **Citrullus vulgaris** Schrad., *F.B.I.*, II, p. 621. (Water Melon.)

Vern. Name: *Turbuz* (Hind.).

Habitat: Cultivated in sandy soil during the hot season.

Uses: The fruit which is sweet and refreshing is much relished. The local fruits, however, are not so sweet as those imported from other parts of India. The juice mixed with sugar and ice is taken as a cooling drink. The seeds are cooling, diuretic and strengthening.

152. **Cucurbita Pepo** DC., *F.B.I.*, II, p. 622.

Vern. Name: *Safed kaddu* (Hind.).

Uses: The fruit is curried. The seeds are described as possessing anthelmintic properties. The leaves are used as external applications for burns (Atkinson, *cf.* Kirtikar)

153. **Coccinia indica** Wight and Arn. Cooke, *Fl. Bomb. Pres.*, Pt. III, p. 538.

Habitat: Found in a few gardens in the city of Hyderabad

Uses: The fruit is curried and even eaten raw.

XXXII. CACTEÆ.

154. **Opuntia Dillenii** Haw., *F.B.I.*, II, p. 657. (The Prickly-pear.)

Vern. Names: *Nag-phanni* (Hind. and Tel.); *Chapalsendh* (Hind.).

Habitat: The plant is said to have been introduced first from South America, but has become naturalized all over India, and in Hyderabad it is a regular pest, being extremely common in waste places round about the city, in villages, on roadsides as hedges and elsewhere.

The cochineal insect was introduced in Aurangabad many years ago as a biological control for getting rid of this *opuntia*.

Uses: The fruit is edible. The branch-joints after being devoid of spines are chopped up and given to cattle in times of scarcity. A red-ink is also made from the ripe fruits. The fruit is considered a refrigerant; the succulent branch mashed up and applied as a poultice is said to allay heat and inflammation (Ainslie). According to Lisboa, the baked fruit is given in whooping cough in the Deccan. The ripe fruit when eaten dyes the urine red. Said to be useful in gonorrhœa. Poultices of joints have been used with marked effect in guinea-worm by Kirtikar.

In Deccan, the milky juice is given as a purgative in doses of ten drops mixed with a little sugar (Tailor).

A syrup of the fruit appears to increase the secretion of the bile and to control spasmodic cough and expectoration (Dymock).

XXXIII. UMBELLIFERÆ.

155. **Peucedanum graveolens** Benth., *F.B.I.*, II, p. 709.

Vern. Names: *Soya*, *Sowa* (Hind.); *Sompa* (Tel.).

Habitat: Cultivated throughout the Dominions.

Uses: The entire plant, except the root, is used in curries. Leaves and fruit are used in medicines. The leaves moistened with oil are used as a stimulating poultice or supperative. An infusion of the herb is given to women after confinement (Dymock).

156. **Coriandrum sativum** Linn., *F.B.I.*, II, p. 717. (Coriander.)

Vern. Names: *Dhania*, *Kotmir* (Hind.); *Dhan yabu* (Tel.).

Habitat: Cultivated all over, also occurs as an escape.

Uses: Leaves (*Kotmir*) and fruits (*Dhania*) form one of the best spices and are much used for flavouring curries. The shoots are very often used in making 'chutney'. The entire plant is of medicinal importance. The dried fruit and the volatile oil are used as an aromatic stimulant in colic. The leaves are chewed to correct foul breath (Kirtikar). The juice of the fresh plant is used as an application to erythema caused by the application of marking nut. Fresh plant rubbed on the forehead gives a cooling and soothing sensation in headache.

157. **Daucus Carota** Linn., *F.B.I.*, II, p. 718. (Carrot.)

Vern. Names: *Gājar* (Hind.); *Pita-kanda* (Tel.).

Habitat: Cultivated extensively throughout the Dominions for its root.

Uses: Carrots are eaten raw, also given to horses. When boiled and made into a paste, and cooked with sugar and milk they make a very delicious sweet (*Gājar-ka-Halva*) which is a refrigerant. Root, leaves, fruit, and seeds are used in medicine for several diseases. The seeds are a nervous tonic. They are considered aphrodisiac and given in uterine pain (Stewart). The fruits are recommended in chronic diarrhœa (Balfour). A poultice made of the roots is used to correct the discharge from ill-conditioned sores (Watt).

158. **Cuminum Cyminum** Linn., *F.B.I.*, II, p. 718.

Vern. Names: *Zira* or *Safed zira* (Hind.).

Habitat: Extensively cultivated in Northern India, but not in the Hyderabad State.

Uses: It is regarded by the Hindu physicians as stomachic, carminative and astringent; useful in dyspepsia and diarrhœa. Used as a cooling medicine in gonorrhœa. (For further information see Kirtikar's *Ind. Med. Pl.*)

XXXIV. RUBIACEÆ.

159. **Gardenia lucida** Roxb., *F.B.I.*, III, p. 115.

Vern. Names: *Dikemali* (Hind.); *Karinga* (Tel.).

Habitat: Found throughout the Dominions in deciduous forests, especially abundant along the Godavari river.

Uses: The gum resin which the tree yields from wounds in the bark and from leaf-buds is sold in the bazaars under the name of *Dikamali*. It has a disagreeable strong odour, and is much used by the native physicians in cutaneous diseases for cleaning bad ulcers and also in cases of worms in children.

160. **Gardenia gummifera** Linn., *F.B.I.*, III, p. 116.

Vern. Names: *Dikemali* (Hind.), *Chit-mit* (Tel.).

Habitat: Found in association with the previous species.

Uses: It is put to much the same uses as the previous species.

161. **Ixora parviflora** Vahl., *F.B.I.* III, p. 142.

Vern. Names: *Mashal-ka-jhar* (Hind.); *Kori*, *Korivi* (Tel.).

Habitat: Common throughout the Hyderabad forests.

Uses: The branches make excellent torches commonly used by postal-runner and people travelling at night, hence the common name *Torch Tree*. 'An oil extracted from the wood is used for cattle-sore' (Partridge). 'The santals employ the root or fruit as a medicine to be given to females when the urine is high coloured' (Rev. A. Campbell, *cf.* Kirtikar).

Other plants described by Partridge in *Forest Flora of Hyderabad* are :—

162. **Adina cordifolia** Hook., *F.B.I.*, III, p. 24.
163. **Stephegyne parvifolia** Korth., *F.B.I.*, III, p. 25.
164. **Hymenodictyon excelsum** Wall., *F.B.I.*, III, p. 35.
165. **Hymenodictyon obovatum** Wall., *F.B.I.*, III, p. 36.
166. **Webera corymbosa**, Willd., *F.B.I.*, III, p. 102.
167. **Randia uliginosa** DC., *F.B.I.*, III, p. 110.
168. **Randia dumetorum** Lamk., *F.B.I.*, III, p. 110.
169. **Randia malabarica** Lamk., *F.B.I.*, III, p. 111.
170. **Gardenia latifolia** Ait., *F.B.I.*, III, p. 116.
171. **Gardenia turgida** Roxb., *F.B.I.*, III, p. 118.
172. **Gardenia florida** Linn., Lamark Ill. i. t. 158, fig. 1 (1797).
173. **Canthium parviflorum** Lamk., *F.B.I.*, III, p. 136.
174. **Canthium didymum** Roxb., *F.B.I.*, III, p. 132.
175. **Ixora nigricans** Br., *F.B.I.*, III, p. 148.
176. **Pavetta indica** Linn., *F.B.I.*, III, p. 150.
177. **Coffea arabica** Linn., *F.B.I.*, III, p. 153.
178. **Morinda tinctoria** Roxb., *F.B.I.*, III, p. 156.
179. **Hamiltonia suaveolens** Roxb., *F.B.I.*, III, p. 197.

XXXV. COMPOSITÆ.

180. **Vernonia anthelmintica** Willd., *F.B.I.*, III, p. 236.

Vern. Name: *Kali ziri* (Hind.).

Habitat: Cultivated for its medicinal properties.

Uses: The seeds are much used by the Hindu physicians in skin diseases, viz. Leucoderma, etc. They are considered as a

powerful anthelmintic and are used in combination with other substances in snake bites (Ainslie, *cf.* Kirtikar, Vol. I, p. 670). They are also used for plasters for abscesses. They are largely used as cattle medicine.

181. **Sphæranthus indicus** Linn., *F.B.I.*, III, p. 275.

Vern. Name : *Mundi* (Hind.).

Habitat : Very common throughout Hyderabad in damp places, fields, etc.

Uses : The seeds and the root possess anthelmintic properties. The powder of the root is considered stomachic. The heads, when dried up, are prescribed along with other medicines by the native physicians in cough and fever, biliousness, etc.

The bark in combination with other drugs is useful in piles.

182. **Chrysanthemum indicum** Linn., Pheede Hort Mal. X.T. 44 (1690), H.F.R.I., 314.

Vern. Name : *Gul-daoodi* (Hind.); this name is applied to all the varieties.

Habitat : Introduced in India from China and Japan. Extensively cultivated throughout Hyderabad for its flowers.

Uses : The plant is considered heating locally. I am informed that this plant is used with other substances in gonorrhœa. The flowers make good garlands which are used by Muslims and Hindus alike. The flowers are also used in temples.

183. **Chrysanthemum coronarium** Linn., *F.B.I.*, III, p. 314.

Vern. Names : *Seoti*, *Seonti* (Hind.); purely local names, also used in Bombay.

Habitat : Introduced in India from the Mediterranean region. Very much cultivated throughout the Dominions for its flowers.

Uses : The flowers are used in making garlands, also used in religious ceremonies. According to Dallzell and Gibson the flowers are a tolerable substitute for chamomile. I am informed that this plant is used in combination with other drugs in gonorrhœa.

XXXVI. MYRSINEÆ.

184. **Embelia ribes**, Burm., *F.B.I.*, III, p. 513.

Vern. Name : *Bai-barang* (Hind., local).

Habitat : Common in the hilly regions.

Uses: The fruit is said to be anthelmintic, carminative, stomachic, alterative and tonic. It is used in intestinal worms, dyspepsia, skin diseases and tape-worms. It is given in milk to children to prevent flatulence. Kirtikar mentions that Dr. Warden has separated an acid, named 'embelic acid', from the seeds.

XXXVII. SAPOTACEÆ.

185. **Bassia latifolia** Roxb., *F.B.I.*, III, p. 544.

Vern. Names: Mohua (Hind. and Mar.); *Ippi-chettu* (Tel.).

Habitat: Very abundant throughout the Dominions, especially on the Telangana side.

Uses: The flowers are eaten either raw or cooked. A spirit (*Mohue-ki-sharab*) is distilled from them and it yields a large revenue to Government. It is said to be appetizing, astringent, heating and tonic. The flowers are regarded as cooling, nutritive and tonic. The fruit is eaten. The oil extracted from it is used in skin diseases. The leaves make a good embrocation (Watt.). The bark is described as astringent and tonic and is said to be useful in itches.

186. **Mimusops Elengi** Linn., *F.B.I.*, III, p. 548.

Vern. Name: Molsari (Hind., local).

Habitat: Cultivated in gardens throughout the Dominions for its fruit.

Uses: The fruit is much relished. The unripe fruit and seeds possess astringent properties. The former is chewed to fix loose teeth. The decoction of the astringent bark makes a good gargle for diseases of the gums and teeth. It is also a tonic. A sweet perfume (*Molasari-ka-itr*) is extracted from the flowers.

187. **Mimusops hexandra** Roxb., *F.B.I.*, III, p. 549.

Vern. Name: Khirni (Hind.).

Habitat: It is cultivated throughout the State for its fruit.

Uses: The fruits are rather tasty and are quite cheap. The bark is exactly similar in properties to that of *Mimusops Elengi*.

188. **Achras sapota** Linn., *F.B.I.*, III, p. 534.

Vern. Name: Chiku.

Habitat: Introduced from America. Cultivated in a few gardens for its fruit. Thrives well in the black cotton soil on the Marhatwari side.

Uses: Fruits ripen from November to March, fairly expensive, but are greatly appreciated.

XXXVIII. EBENACEÆ.

189. **Diospyros melanoxylon** Roxb., *F.B.I.*, III, p. 564.

Vern. Name: *Abnoos.*

Habitat: Common in the Telangana forests.

Uses: The tree produces good ebony. The bark possesses astringent properties and is used in diarrhœa and dyspepsia. It is also used in dilute decoction as an astringent lotion for the eyes.

XXXIX. OLEACEÆ.

190. **Jasminum Officinale** Linn , *F.B.I.*, III, p. 603. (The common white garden jasmine.)

Vern. Name: *Chambeli* (Hind.).

Habitat: Very commonly cultivated in gardens for its flowers.

Uses: Flowers are used for making garlands and bouquets. Hair oil (*chambeli-ka-tel*) as well as a lovely perfume is extracted from them. The root is of medicinal value, being useful in ring-worm (Honnigberger).

191. **Jasminum Sambac** Ait , *F B.I.*, III, p. 591.

Vern. Names: *Motia*, *Mogra*, *But-mogra* (Hind.); *Botumalle* (Tel.); *Bela* (Mar.).

Habitat: Cultivated extensively throughout the Dominions for its sweet-scented flowers. I have seen this species wild in the forests of Pakhal, Muluk (Warangal District), and Adilabad District.

Uses: Flowers are used by the Hindus and Muslims alike in making garlands which are used in various ceremonies, marriages, feasts and the like. Jasmines are also put on graves. Hair oil (*Motia-ka-tel*) as well as a sweet perfume, otto de mothia (*Motia-ka-itr*) are extracted from them. Leaves and flowers are used in native medicine. The former dried, soaked in water and made into a poultice are used in indolent ulcers (Watt). The flowers possess a considerable power as a lactifuge.

192. **Jasminum pubescens** Willd., *F B.I.*, III, p. 592.

Vern. Names: *Mogra*, *Chambeli* (Hind.); *Advi-malle* (Tel.).

Habitat : Wild enough in forests throughout, especially on the Telangana side.

Uses : Flowers utilized for making garlands. Root is said to be a good antidote for snake-bite. Leaves also are used for certain ulcers.

193. **Jasminum Grandiflorum** Linn., *F.B.I.*, III, p. 603.

Vern. Name : Chambeli (Hind.)

Habitat : Grown in gardens and houses.

Uses : Leaves and flowers are used in medicine by the native physicians. The scented oil is considered very cooling. Leaves are used by Hindu physicians in skin diseases, ulcers of the mouth, etc The flowers are applied in the form of plaster to the loins and pubes as an aphrodisiac (Dymock).

194. **Jasminum humile** Linn., *F.B.I.*, III. p. 602.
(The yellow Jasmine.)

Vern. Name : Pilee chambeli (Hind.).

Habitat : Often cultivated in gardens. It is stated to grow wild in the hills of Hyderabad.

Uses : The root is useful in ringworms (Honnigberger).

195. **Jasminum arborescens** Roxb., *F.B.I.*, III, p. 594.

Vern. Names : Chambeli, Jangli Mogra (Hind.); *Kusar* (Mar.).

Habitat : It is recorded in *The Forest Flora of the State* as common on the ghats in Aurangabad.

Uses : The juice of the leaves is used, with pepper, garlil and other stimulants as an emetic, in obstruction of the bronchiac tubes by viscid phlegm (Dymock).

196. **Jasminum dispermum** Wall., *F.B.I.*, III, p. 602.

Vern. Name : Chambeli.

197. **Nyctanthes Arbotristis** Linn., *F.B.I.*, III, p. 603.

Vern. Names : Harsingar (Hind.); *Karsha* (Tel.); *Kaisar* (Mar.).

Habitat : Abundant in the jungle all over, also found near temples, and cultivated in gardens.

Uses : Leaves and bark are used in medicine for fevers and sciatica. Flowers used for garlands. A dye is extracted from the orange-coloured corolla-tubes. The expressed juice

of the leaves is given with a little sugar to children as a remedy for intestinal worms (Kirtikar).

198. **Schrebera swietenioides** Roxb., *F.B.I.*, III, p. 604.

Vern. Name: *Mokhab* (Tel.).

Habitat: So far as I have been able to ascertain, it is found in a few forests on the Telangana side.

199. **Ligustrum neilgherrense** Wight., *F.B.I.*, III, p. 615.

Vern. Name: *Kangain* (Mar.).

Habitat: Limited to the hills on the Marhatwari side (Ajanta hills).

XL. APOCYNACEÆ.

200. **Vinca rosea** Linn., *F.B.I.*, III, p. 640.

Vern. Names: *Sada-bahar* (Hind.); *Billa-ganeru* (Tel.).

Habitat: Very common in gardens and near fields.

Uses: It is not used for any purpose here locally, but according to Surgeon Major P. N. Mukerji, the juice of the leaves is employed in Orissa as an application to wasp stings.

201. **Carissa Carandas** Linn., *F.B.I.*, III, p. 630.

Vern. Names: *Karaunda* (Hind.); *Kali-kai* (Tel.).

Habitat: Commonly cultivated in gardens throughout the Dominions. Also a hedge plant.

Uses: Ripe fruits eaten though not much relished. Unripe fruits are curried. Leaves, root, and fruit are of medicinal importance. The unripe fruit is astringent and the ripe fruit is cooling, acid and useful in bilious complaints. Root reputed as a bitter stomachic, used in some places for itch. The fruit possesses antiscorbutic properties.

202. **Carissa spinarum** A.DC., *F.B.I.*, III, p. 631.

Vern. Names: *Karaunda* (Hind.); *Kali-kai* (Tel.).

Habitat: Wild in the forests all over, near villages, in hedges, on tank-bunds, etc.

203. **Plumeria acutifolia** Poir., *F.B.I.*, III, p. 641. (The Pagoda Tree or Temple Tree.)

Vern. Names: *Khair-champa* (Hind.); *Vada ganneru*, *Modu-ganer* (Tel.).

Habitat: Frequently found in temples, commonly cultivated in gardens, compounds and roadsides.

Uses: The flowers are very fragrant and are made into garlands and used by Hindus in their temples. Bark, leaves, juice, branches and flower-buds are of medicinal importance. The root bark is a strong purgative, also useful in gonorrhœa and for venereal sores. Plasters made of the bark are useful in dispersing hard tumours (*Ph.I.*). A poultice of the leaves is useful in dispelling swellings. 'Sap mixed with cocoanut is used as a remedy foı itch' (Talbot).

204. **Wrightia tinctoria** Br., *F.B.I.*, III, p. 653.

Vern. Names: *Kala inderjau* (Hind.); *Pala-kordsha* (Tel.).

Habitat: Abundant in the jungles, on roadsides throughout the Dominions.

Uses: Root-bark and seeds are of medicinal importance. The bark is used as a tonic, and the seeds as an aphrodisiac. The root-bark and seeds are used as substitutes for Holarrhena anti-dysenterica.

205. **Nerium odorum** Soland., *F.B.I.*, III, p. 655.
(The Oleander.)

Vern. Names: *Ganer* (Hind.); *Ganneru* (Tel.).

Habitat: Grown in gardens all over the Dominions, found wild on sandy banks all along the Ghat-hills on the Marhatwari side—Aurangabad, Daulatabad and other places.

Uses: Bark and roots are poisonous, and as such, are used for criminal and suicidal purposes, and are also of medicinal importance. Roots used in skin diseases and inflammatory affections. A decoction of the leaves is prescribed for reducing swellings. An oil prepared from root-bark is useful in leprosy, etc.

206. **Holarrhena anti-dysenterica** Wall., *F.B.I.*, III, p. 644.

Vern. Names: *Inderjau*, *Dudhia* (Hind.); *Istari-pala*, *Kola-muka* (Tel.).

Habitat: Found all over as a roadside plant, also very common in forests.

Uses: As the name suggests, its bark is a sure remedy for dysentery. So are the seeds. 'An infusion of the roasted seeds is a gentle and safe astringent in bowel complaints, and is given to allay the vomiting of cholera'. (Ainslie, *Mat. Ind.*, Vol. II, p. 483). The seeds are attributed astringent, carminative, tonic and aphrodisiac properties. They are useful in chest affections, fever, bowel complaints, piles, intestinal worms, etc.

Other cultivated plants recorded are :—

207. **Allamanda cathartica** Linn., Cook, *Fl. Bomb. Pres.*, II, Pt. I, p. 144.

Habitat : Commonly cultivated in gardens.

208. **Thevetia nerifolia** Juss, Cook, *Fl. Bomb. Pres.*, II, Pt. I, p. 144. (The yellow Oleander.)

Vern. Name : Pila ganer (Hind.).

Habitat : A very common garden plant, cultivated everywhere and often found wild.

209. **Ichnocarpus frutescens** R.Br., *F.B.I.*, III, p. 669.

Vern. Name : Nalla tiga (Tel.).

Habitat : A fairly common climber in the forests along the Godavari.

Uses : The root is considered to possess alterative tonic properties, and has been employed as a substitute for Sarsaparilla (*Ph. Ind.*). A decoction of the stalks and leaves is used in fevers (Watt).

210. **Beaumontia grandiflora** Wall., *F.B.I.*, III, p. 660.

Habitat : A native of Nepal, commonly grown in the State as an ornamental plant.

Uses : A fibre is prepared from the young twigs (Watt, *Dict. Econ. Prod.*, Vol. I, p. 434).

XLI. ASCLEPIADEÆ.

211. **Cryptostegia grandiflora** Br., *F.B.I.*, IV, p. 6.

Vern. Name : Vilayati vakundi (Mar.).

Habitat : Found along roadsides, in gardens, and compounds of houses.

212. **Calotropis gigantea** Br., *F.B.I.*, IV, p. 17.

Vern. Name : Ak.

Habitat : Very common in villages, and on waste lands all over.

Uses : Juice of the leaves is supposed to be an antidote for snake-bite. The root, bark, and flowers are of great medicinal importance (Kirtikar). The root-bark is said to promote the secretions and to be useful in skin diseases, enlargements of the abdominal viscera, intestinal worms, cough, etc. The milky

juice is regarded as a drastic purgative and caustic. The flowers are considered digestive, stomachic and tonic and useful in loss of appetite, cough, asthma, etc. (Kirtikar).

213. **Holostemma Rheedei** Wall., *F.B.I.*, IV, p. 21.

Vern. Name: Pala-gurji (Tel.).

Habitat: Recorded as a hedge-plant (Partridge, *Forest Flora of Hyderabad, Deccan*).

Use: Its root is said to be used in diseases of the eye.

214. **Hemidesmus indicus** R.Br., *F.B.I.*, IV, p. 5.

Vern. Name: Usbha-i-hindi.

Habitat: Wild, especially towards Warangal side.

Uses: The roots are used as a substitute foı Sarsaparilla. 'They are said to be sweet, demulcent, alterative, diaphoretic, diuretic and tonic. Useful in loss of appetite, disinclination for food, fever, skin diseases, syphilis and leucorrhœa' (Dutt's *Materia Medica*, *cf.* Kirtikar, Pt. II, p. 808).

For further information see Watt, *Dict. Econ. Prod.*, I, *Pharmacographic indica* (p. 448).

215. **Caralluma attenuata** Wight., *F.B.I.*, IV, p. 76.

Habitat: Wild throughout.

XLII. LOGANIACEÆ.

216. **Strychnos Nux vomica** Linn., *F.B.I.*, IV, p. 90.
(Nux vomica or Strychnine tree.)

Vern. Names: Kuchla (Hind.); *Mushti* (Tel.).

Habitat: Found in extreme abundance in Pakhal, Muluk, and Adilabad district of the Hyderabad State, so much so that the water of many ponds and streams of these places is *kuchla*-infested and is very carefully used.

Uses: All parts of the plant are of great medicinal importance. Nux vomica seeds are aphrodisiac; they are used in dyspepsia and diseases of the nervous system. Nux vomica is very useful in palsy, relaxation of the muscles and tendons, debility and chronic rheumatism (Makhzan). Seed is a valuable nervine tonic and stimulant, useful in paralytic and neuralgic affections in atonic diarrhœa and chronic dysentery, in habitual constipation, in prolapsus of the rectum, speımatorrhœa, etc. (Pharmacographic indica.). It has also been used in fevers, epilepsy, diabetes, anæmia, chlorosis, etc.'

XLIII. BORAGINACEÆ.

217. **Trichodesma indicum** Br., *F.B.I.*, IV, p. 153.

Vern. Names : *Chota Kulfa* (Hind.) ; *Gusva-gutti* (Tel.).

Habitat: Throughout the Dominions, in fields. Occurs more abundantly on the Telangana side.

Uses : Leaves and root are of medicinal importance, being used for snake-bites, swellings, etc.

218. **Trichodesma amplexicaule** Roth., *F.B.I.*, IV, p. 153.

Habitat : Wild, commonly found in fields, amongst hedges, waste places, etc.

219. **Cordia Rothii** Raem and Sch., *F.B.I.*, IV, p. 138.

Vern. Names : *Gondni* (Hind.) ; *Bokur* (Mar.).

Habitat: Quite common round about Hyderabad, also generally met with near cultivated grounds and villages.

Uses : The pulp of the fruit is eaten. The decoction of the bark possesses astringent properties and is used as a gargle (*Ph. Ind.*).

220. **Cordia Myxa** Linn., *F.B I.*, IV, p. 136.

Vern. Names : *Bar-gondni, Lasura* (Hind.) ; *Sepistan* (Pers.) ; *Pedda Irki* (Tel.) ; *Bakar* (Mar.).

Habitat: Quite common in forests throughout the Dominions ; often cultivated for its fruit.

Uses : The fruit 'Sepistan' is eaten, and is used in indigenous medicine for cough. The seeds *Chakun-ki-bij*, wood and bark are also medicinal, being a good remedy in ringworm. Teeth are rubbed with the bark to strengthen them. The bark contains a large amount of tannic acid. The raw fruits are pickled.

221. **Heliotropium curassavicum** Linn., Mayuranathan, *Flora of Madras City*, p. 189.

Habitat : Commonly found in fields.

XLIV. CONVOLVULACEÆ.

222. **Ipomœa Batatas** Lamk., *F.B.I.*, IV, p. 202. (Sweet potato.)

Vern. Names : *Ratālu, Lāl ālu* or *Shakkurkund* (Hind.) ; *Kanda-gadda* (Tel.).

Habitat: Commonly cultivated throughout the Dominions.

Uses: The tubers, which are either red or white, are eaten after boiling them and are made into tasty sweets.

223. **Ipomœa hederacea** Jacq., *F.B.I.*, IV, p. 199.

Habitat: Wild in waste places.

224. **Cuscuta reflexa** Roxb., *F.B.I.*, IV, p. 225.
(The Dodder.)

Vern. Name: *Passi tiga* (Tel.).

Habitat: Common in open jungles throughout the Dominions. It is found growing on *Zizyphus* and other trees.

Uses: The seeds are considered carminative, and for this purpose are boiled and placed over the stomach (Kirtikar). The stem is said to be useful in bilious disorders (*Bombay Gazetteer*). The seeds are purgative.

225. **Evolvulus alsinoides** Linn , *F.B.I.*, IV, p. 220.

Habitat: Commonly wild on lands and waste places.

226. **Convolvulus arvensis** Linn., *F.B.I.*, IV, p. 219.

Habitat: Wild throughout.

227. **Argyreia speciosa** Sweet., *F.B.I.*, IV, p. 185.
(Elephant Creeper.)

Vern. Names: *Samandar-sok*; *Samandar-ka-pat* (Hind.); *Kaf-i-darya* (Pers.); *Samudra-pala* (Tel.).

Habitat: Fairly abundant round about the city of Hyderabad.

Uses: In Hindu medicine, the root is regarded as alterative, tonic and useful in rheumatic affections and diseases of the nervous system (Dutt, *cf.* Kirtikar, p. 872). The leaves are used as emollient poultices for wounds and externally in skin diseases. Mixed with vinegar the sap is rubbed over the body to reduce obesity (Watt).

XLV. SOLANACEÆ.

228. **Solanum tuberosum** Linn., Cook, *Fl. Bomb. Pres.*, II, Pt. II, p. 269. (Potato.)

Vern. Names: *Ālu* (Hind.); *Alu-gudda* (Tel.).

Habitat: Extensively cultivated all over Hyderabad for its tubers.

Uses: The tubers or the potatoes are used as food in various forms and are almost indispensable.

229. **Solanum Melongena** Linn., *F.B.I.*, IV, p. 235.
(The Egg Plant; Brinjal.)

Vern. Names: *Baingan* (Hind.); *Wankailu* (Tel).

Habitat: Cultivated throughout for its fruit.

Uses: Fruit is used in curries. The seeds are used as a stimulant and the leaves as a narcotic (Atkinson). The seeds are apt to lead to dyspepsia and constipation (Stewart). It is for this reason, I think, that the local physicians prohibit its use to patients suffering from fever or cough. As a matter of fact they consider it injurious for patients suffering from any disease.

230. **Solanum nigrum** Linn., *F.B.I.*, IV, p. 229.

Vern. Names: *Kamunni, Makoi* (Hind.); *Kanchi-pundu* (Tel.).

Habitat: A common weed in gardens, and also cultivated in fields throughout Hyderabad.

Uses: According to Dutt, the berries are considered tonic, diuretic and useful in anasarca and heart diseases. In Bengal, the berries are employed in fever, diarrhœa, eye-diseases, hydrophobia, etc. (T. K. Mukerji.) In the U.P., the juice is used in blood-spitting, piles, dysentery, etc. In Bombay, the juice is given in doses of six to eight ounces in the treatment of chronic enlargement of liver, and is considered a valuable alterative (Dymock).

The juice acts as an expectorant and diaphoretic (S. Arjun).

Locally the juice of the plant is boiled until it loses its green colour and when reddish brown is taken off the fire, strained, cooled, and then administered. About half a cup to three-fourths of it is the usual quantity taken at a time. It does help to reduce the enlarged liver.

231. **Solanum xanthocarpum** Schrad and Wendl., *F.B.I.*, IV, p. 236.

Vern. Names: *Kutia, Sial-kanta* and *Kantikari* (Beng.): *Dorli-ka-phal* (Hind.); *Kuda* (Tel.).

Habitat: Abundant throughout Hyderabad on waste ground, by roadsides, etc.

Uses: The root is used in cough, asthma, catarrhal fever and pain in the chest (Kirtikar, II, p. 897).

The roots beaten up and mixed with wine are given to check vomiting. The juice of the berry is also useful in sore-throat

(Agra Exhibition, *cf.* Kirtikar). The stems, flowers and fruit, according to Dr. Wilson (*Calcutta Med. Phys. Trans.*, II, p. 406), are bitter and carminative, and are prescribed in those forms of the burning of the feet (Ignipeditis), which are attended with a vesicular, watery eruption. Toothache is said to be cured by fumigations with the vapour of the burning seeds of this plant. According to Dr. Peters of the Bombay Medical Service, the plant is much used in Bengal as a diuretic in dropsy. In the Punjab hills, the expressed juice of the leaves is given with black pepper in rheumatism. A decoction of the plant is used in cases of gonorrhœa. 'The bud and flower, with salt (solution) good for watery eyes' (J. J. Wood's *Plants of Chutia Nagpur*, p. 122).

232. **Solanum verbascifolium** Linn., *F.B.I.*, IV, p. 230.

Habitat: Rare plant, found in damp shady places near villages, probably as an escape.

233. **Datura fastuosa** Linn., *F.B.I.*, IV, p. 242.

Vern. Names: *Kaladhatura* (Hind.); *Nall-ummetta* (Tel.).

Habitat: Common throughout Hyderabad in waste places.

Uses: The seeds are a favourite poison for criminal purposes The seeds and their preparations are employed by roadside thieves for stupefying their victims. They are also used for making intoxicating liquor. The seeds, leaves and fresh juice are narcotic, anodyne, and antispasmodic (Kirtikar, Vol II, p. 914). An alkaloid, Daturine, is useful as a substitute for Belladona, and is prepared from the seeds (Kanai Lal De Bahadur). According to Dr. Aswald, immediate relief follows smoking a small quantity of the leaves in cases of asthma (*Ph. Ind.*). The juice of fresh leaves or their poultice is useful for painful swellings, the former being also useful in ophthalmic pain (D. Basu). The juice of fresh leaves is useful in ear-ache, a drop or two are poured inside the ear (T. N. Ghose). In Mysore, the juice of the leaves is given once daily with curdled milk for gonorrhœa (North).

234. **Datura alba** Nees., *F.B.I.*, IV, p. 243.

Vern. Names: *Safed dhatura* (Hind.); *Ummetta, dhutturamu* (Tel.).

Habitat: Common throughout Hyderabad in waste places.

Uses: The seeds are supposed to be not so deadly as those of *D. fastuosa*. 'In Hindu medicine, the root of *D. alba* is boiled in milk, and this milk is administered with clarified butter and treacle in insanity. The seeds, leaves and roots are con-

sidered useful in insanity, fever, with catarrhal and cerebral complications, diarrhœa, skin diseases, lice, etc.' (Dutt). 'Epithems of the bruised leaves, or embrocation formed by macerating the bruised seeds in any bland oil, are often very effectual in allaying the pain in rheumatic swellings, nodes, boils, and tumours' (*Pharmacopeia Indica*).

235. **Nicotiana Tabacum** Linn., *F.B.I.*, IV, p. 245. (Tobacco Plant.)

Vern. Names: *Tambaku* (Hind.); *Pogako* (Tel.).

Habitat: Cultivated in almost every village throughout the Dominions.

Uses: Officinal in both Indian and British Pharmacopeias. Two important preparations of tobacco are made in Hyderabad: (i) *Khamira*—It is a mixture of finely powdered tobacco, musk, and other things, prepared in a special manner. When ready it is mixed with fine silver-sheets (*waraq*), and eaten with *Pan* (betel-leaf). It is usually so strong that at the most only half a gram size can be taken at a time. (ii) *Gudaku*—It is prepared with tobacco, *Gur* (raw sugar), and other substances. It is of a black colour, and is made into round discs of varying thickness and weights. This tobacco preparation is used in 'Hubble-bubbles'.

236. **Nicotiana plumbaginifolia** Viv., *F.B.I.*, IV, p. 246.

Habitat: A plant was found growing at the base of an old wall near a gutter.

237. **Lycopersicum esculentum** Mill., *F.B.I.*, IV, p. 237. (Tomato.)

Vern. Names: *Vilayati baingan* (Hind.).

Habitat: Cultivated extensively all over.

Uses: Too well known as a table favourite, being used in salads and curries.

238. **Capsicum frutescens** Linn., *F.B.I.*, IV, p. 239. (Chilly.)

Vern. Names: *Lāl Mirch* (Hind.); *Mirpa* (Tel.).

Habitat: Extensively cultivated all over for its fruit.

Uses: Chillies are an essential ingredient of Indian curries. They are used by Indian physicians in cholera, dyspepsia, intermittent fevers and typhus. Externally, they are used as

rubefacient and internally, used as stomachic (Atkinson). 'A dose of ten grains of finely powdered capsicum seed, given with an ounce of hot water, two or three times a day, sometimes shows wonderful effects in cases of delirium tremens' (Surg. Major Gray, Lahore).

XLVI. SCROPHULARINEÆ.

239. **Torenia asiatica** Linn., *F.B.I.*, IV, p. 277.

Habitat: Commonly cultivated in gardens throughout the Dominions.

Uses: According to Kirtikar, the juice of the leaves is considered a cure for gonorrhœa on the Malabar coast (Rheede). But as far as I know they are not put to any use locally.

240. **Antirrhinum majus** Linn., Cooke, *Fl. Bomb. Pres.*, II, Pt. II, p. 309. (Snapdragon.)

Habitat: Grown in gardens as an ornamental plant.

241. **Lindenbergia urticæfolia** Lehm., *F.B.I.*, IV, p. 262.

Uses: The juice is of medicinal importance, being given in chronic bronchitis, also applied with that of coriander to skin eruptions (Kirtikar).

XLVII. BIGNONIACEÆ.

242. **Millingtonia hortensis** Linn., *F.B.I.*, IV, p. 377. (Indian Cork Tree.)

Vern. Name: *Akas-nim* (Hind.).

Habitat: Grown in gardens, avenues, on roadsides.

243. **Kigelia pinnata** DC., Cooke, *Fl. Bomb.*, II, p. 336. (Cucumber tree, Sausage tree.)

Habitat: Planted round about Hyderabad in gardens.

Uses: The Tongas apply the powdered fruit as a dressing to ulcers. The ripe fruit is not edible (Stevenson-Hamilton), but is purgative. The unripe fruit is used in Central Africa as a dressing in case of syphilis and rheumatism (Watt and Breyer-Brandwijk).

244. **Oroxylon indicum** Vent., *F.B.I.*, IV, p. 378.

Vern. Names: *Dundilum*, *Pampenachettu* (Tel.).

Habitat: Met with throughout the Dominions.

Uses: Bark and seeds are of medicinal importance. Root-bark is used in native medicine for diarrhœa and dysentery. Seeds purgative.

245. **Stenolobium stans** Seem., Cooke, *Fl. Bomb. Pres.*, II, Pt. II, p. 335.

Habitat: A native of America. Extensively planted as an ornamental shrub.

246. **Spathodea campanulata** Beauv., Fl.D'Owen., Cooke, *Fl. Bomb. Pres.*, II, Pt. II, p. 335. (The Fountain Tree; the Flame Tree).

Habitat: A native of tropical Africa. Planted as a road-side tree.

XLVIII. PEDALINEÆ.

247. **Sesamum indicum** DC., *F.B.I.*, IV, p. 387.

Vern. Name: *Til* (Hind.).

Habitat: Cultivated extensively throughout the Dominions.

Uses: The seeds known as *Til* are used in curries. An oil extracted from them, *Tilli-ka-tel*, is also used in certain curries instead of ghee (clarified butter).

The seeds are considered emollient, nourishing, tonic, diuretic, and lactagogue. They are useful in piles. Both the seeds and the oil are used with other medicines in dysentery and urinary diseases. A decoction of the seeds, sweetened with sugar, is prescribed in cough, etc. A poultice made of the seeds is applied to ulcers, burns, etc. A lotion made from the leaves is supposed to be a good hair-wash; a decoction of the root is used for the same purpose. The seeds possess powerful emmenagogue properties. (For further information refer to Kirtikar and Watt's Dictionary.)

After extracting the oil from the seeds the waste is given to cattle, and it forms an excellent food.

248. **Pedalium Murex** Linn., *F.B.I.*, IV, p. 386.

Vern. Names: *Fareed-buti*, *Bara gokhru* (Hind.); *Pedda-palleru* (Tel.): *Mothe-gokharu.*

Habitat: It grows very wild.

Uses: An infusion of fresh leaves and stems in cold water is a highly prized remedy amongst the people of Southern India, in gonorrhœa and dysuria (Kirtikar). Fruits are said to be demulcent, diuretic, antispasmodic and aphrodisiac. 'The mucilaginous water derived from the leaves is useful in

unnatural heat of the kidneys and the ardour urinæ. It relieves strangury, and dissolves calculi.'

249. **Martynia diandra** Glox., *F.B.I.*, IV, p. 386.
(Tiger's claw or Devil's claw.)

Vern. Name: *Bichchu* (Hind.).

Habitat: Said to be an American weed, but it is very wild in Hyderabad, occurring in fields and waste places.

Uses: The fruit is rubbed down with water and applied externally for scorpion sting (Kirtikar, *Ind. Med. Pl.*, Pt. II, p. 950).

XLIX. ACANTHACEÆ.

250. **Andrographis paniculata** Nees., *F.B.I.*, IV, p. 501.

Vern. Names: *Charayetah, chiraita* (Hind.); *Nelavemu* (Tel.). Real *Chiraita* is Swertia Chirata.

Habitat: Throughout the Telangana Districts, especially in Adilabad, Muluk, Pakhal, etc.

Uses: The shoots and roots have many important medicinal properties. The commonest use, to which this drug is put, is in checking malaria, also dysentery and diarrhœa. It is so far the best substitute for quinine, and the *Unani* physicians, who do not make use of quinine, prescribe *charayetah* infusion. It is also used for purifying the blood, for instance, an infusion of this drug is given to patients suffering from itches. The bitter principle is said to be a crystalline glucoside—'*andrographid*.' (Boorsma).

251. **Justicia Gendarussa** Linn., *F.B.I.*, IV, p. 532.

Vern. Names: *Oodi-shambalu* (Hind.); *Nall-vavili* (Tel.).

Habitat: I have noticed it along the fields a little away from the roadside in Pakhal (Telangana side).

Uses: Locally, the juice of the leaves is dropped in the ear for ear-ache.

252. **Barleria cuspidata** Heyne., *F.B.I.*, IV, p. 483.

Habitat: It is found everywhere in fields and waste ground in rather dry situations.

253. **Justicia Betonica** Linn., var. **ramosissima**, Roxb., *F.B.I.*, IV, p. 525.

Habitat: Common in the hills; also cultivated.

254. **Lepidagathis cristata** Willd., *F.B.I.*, IV, p. 516.

Habitat: Wild throughout the Dominions in rather dry areas.

L. VERBENACEÆ.

255. **Lantana Camara** Linn., *F.B.I.*, IV, p. 562.

Habitat: Found all over the Dominions, especially along roadsides and waste places; very often amongst *Cactus* plants.

(For further information refer to my articles in 'Current Science', Vol. I, No. 10, April 1933, p. 330, and Vol. II, No. 3, September 1933, p. 83.)

256. **Tectons grandis** Linn., *F.B.I.*, IV, p. 570.

Vern. Names: *Sagwan* (Hind.); *Teku* (Tel.).

Habitat: One of the most prominent forest trees of the Dominions.

This is the principal species in the hill-forests. Found along the right bank of Godavari, also in the Warangal District, viz. Pakhal, and Adilabad District.

Uses: This tree is of great economic and medicinal importance, and its uses are too well known to be enumerated in detail here. Furniture, beams, trusses, rafters, doors, window-frames, flooring, stair-cases, carts, agricultural implements are made out of teak. Teak-wood oil is of medicinal importance, being used as a substitute for linseed oil and as varnish. A plaster of the powdered wood is recommended in hot headaches and for the dispersion of inflammatory swellings. Taken internally it is efficacious in dyspepsia with burning of stomach. It is also vermifuge. The bark is astringent and the flowers are diuretic.

257. **Duranta plumieri** Jacq., Cooke, *Fl. Bomb.*, II, p. 437.

Habitat: Extremely common round about the city, grown as a hedge plant. Native of South America and the West Indies (Cooke).

LI. LABIATÆ.

258. **Ocimum canum** Sims., *F.B.I.*, IV, p. 607.

Vern. Names: *Safed tulsi* (Hind.); *Kukka-tulasi* (Tel.).

Habitat: Abundant in gardens.

Uses: During high fever when hands and feet are cold, the leaves made into a paste, are applied to the fingers and toe-nails.

259. **Ocimum gratissimum** Linn., *F.B.I.*, IV, p. 607.

Vern. Name: *Ram-tulsi.*

Habitat: Cultivated near temples.

Uses: The juice of the leaves mixed with a little honey is often prescribed by Indian physicians for cold, especially for infants. The juice is also applied externally in cutaneous diseases. Dried leaves when burnt, drive away mosquitoes. The decoction of the roots is given in malarial fevers. Seeds are demulcent, and are given in disorders of the genito-urinary system. The juice of the fresh leaves dropped into the ear is a good cure for ear-ache.

260. **Ocimum Basilicum** Linn., *F.B.I.*, IV, p. 608.

Vern. Names: *Sabza* (Hind.); *Raihan* (Arab.); *Rudra-jeda* (Tel.).

Habitat: Commonly cultivated.

Uses: The seeds are mucilaginous and cooling. They are soaked in water, and when they swell up more water is added with enough sugar to sweeten them, then with the addition of milk and ice a very refreshing drink (sherbat) is obtained. An infusion of the seeds is given in gonorrhœa, diarrhœa, and chronic dysentery. Bruised leaves are useful for scorpion stings, and their juice is recommended for ringworms. Roots are used for the bowel complaints of children. The essential oil contains 'ocimene'.

261. **Ocimum sanctum** Linn., *F.B.I.*, IV, p. 609.

Vern. Names: *Tulsi, Kali tulsi* (Hind.): *Tulasi, gaggera-chettu* (Tel.).

Habitat: Commonly grown in gardens, in temples all over the Dominions. Also found in waste places.

Uses: Same as of *O. gratissimum* Linn.

262. **Mentha viridis** Linn., *F.B.I.*, IV, p. 647.
(The common mint.)

Vern. Names: *Pudinah* (Hind.); *Pudina* (Tel.).

Habitat: Cultivated in gardens throughout the Dominions. Strongly scented perennial herb with suckers.

Uses: The leaves are used for flavouring curries. Oil extracted from the leaves is of medicinal and economic importance. The well-known *Pudina-ki-chatni* is prepared from the leaves, mixed with a little of tamarind, salt, and sugar. It is refrigerant and stomachic, checks bile and vomiting. Leaves are given in fever and bronchitis.

263. **Salvia farinacea** Benth., Cooke, *Fl. Bomb. Pres.*, II, Pt. III, p. 475.

Habitat: I have not yet had the opportunity of ascertaining its habitat definitely. The flowering shoots were brought to

me from the compound of the office of the Director of Agriculture (Station Road, Hyderabad).

LII. NYCTAGINEÆ.

264. **Mirabilis Jalapa** Linn., Cooke, *Fl. Bomb. Pres.*, II, Pt. III, p. 483.

Vern. Name: *Gul-i-Abbas.*

Habitat: Commonly grown in gardens, and houses as an ornamental plant.

265. **Bougainvillea spectabilis** Willd., Cooke, *Fl. Bomb. Pres.*, II, Pt. III, p. 483.

Habitat: Commonly grown in gardens.

266. **Bougainvillea glabra** Choisy., Cooke, *Fl. Bomb. Pres.*, II, Pt. III, p. 483.

Habitat: Commonly grown in gardens.

267. **Boerhaavia diffusa** Linn., Cooke, *Fl. Bomb. Pres.*, II, Pt. III, p. 480.

Habitat: Very abundant throughout in fields, hedges, etc

Uses: Santals use it in food as well as in medicine. Watt suggests that this hardy perennial herb would make a good fodder for cattle. It is given to cattle in Bengal as a medicinal food and is supposed to increase the quantity of milk. Infusion of the root or the powder is used as a laxative, diuretic, anthelminthic, and cooling medicine. It is a good expectorant and is useful in asthma. It possesses emetic properties also. A poultice of the leaves is said to be useful in abscesses. (For further information see Watt, *Dict. Econ. Prod.*, I.B., p. 486.)

LIII. AMARANTACEÆ.

268. **Celosia argentea** Linn., *F.B.I.*, IV, p. 73.

Vern. Name: *Safed murgha* (Hind.).

Habitat: Wild all over, growing in fields, gardens and compounds of houses.

Uses: The seeds are efficacious in diarrhœa. Taken with other substances they are a powerful aphrodisiac.

269. **Amarantus spinosus** Linn., *F.B.I.*, IV, p. 718.

Vern. Names: *Kante mat* (Hind.) ; *Nalla doggali* (Tel.).

Habitat: Wild throughout Hyderabad, growing in waste places, fields and gardens.

Uses: The leaves are curried. The herb is 'considered light, cooling and promoter of the alvine and urinary discharges' (*cf.* Kirtikar). The root is a specific for colic and gonorrhœa. The whole plant is an antidote for snake-poison.

LIV. CHENOPODIACEÆ.

270. **Spinacia oleracea** Linn., *F.B.I.*, V, p. 6.

Vern. Names: *Palak* (Hind.); *Palang* (Beng.); *Palak Bhaji* (Mar.).

Habitat: Extensively cultivated throughout Hyderabad as a rainy-season crop.

Uses: The shoots are curried. Spinach is considered very cooling and refrigerant by the *Unani* physicians. The seeds are cooling and laxative.

LV. PHYTOLACCACEÆ.

271. **Rivinia humilis** Linn., Mayuranathan, *Flora of Madras City*, p. 251. (Blood Berry.)

Habitat: Found as an escape in gardens and elsewhere.

LVI. POLYGONACEÆ.

272. **Rumex vesicarius** Linn., *F.B.I.*, V, p. 61. (Sorrel.)

Vern. Names: *Chooka*, *Chuka* (Hind.).

Habitat: Cultivated throughout the Dominions.

Uses: The leaves are used in curries. The juice, seeds, and root are medicinal. It is considered very cooling. The seeds are a valuable antidote for insect bites and dysentery. The juice is comforting in toothache, also useful in heat of stomach.

LVII. PIPERACEÆ.

273. **Piper betle** Linn., *F.B.I.*, V, p. 85.

Vern. Names: *Pan-ki-bel* (Hind.); *Tamal-pakoo* (Tel.).

Habitat: Widely cultivated for its leaf. Requires plenty of water and shade.

Uses: The betel-leaf (*Pan*) is universally chewed in the State.

LVIII. LAURACEÆ.

274. **Litsæa polyantha** Juss., *F.B.I.*, V, p. 162.

Vern. Names: *Jangli-rai-am*, *Maida-lakri* (Hind.).

Habitat: Found on the Aurangabad Ghats (Partridge, *Forest Flora of Hyderabad*).

Uses: An oil is extracted from the berries. The bark is used in medicine, and is a mild astringent, and has a considerable degree of balsamic sweetness (Ainslie). According to Campbell, the powdered bark is applied to the body for pains arising from blows or bruises, or from hard work; it is also applied to fractures in animals.

275. **Litsæa sebifera** Pers., *F.B.I.*, V, p. 157.

Vern. Names: *Narra-ma-midi*, *Nara-chettu* (Tel.); *Maidalakri* (Hind. and Mar.).

Habitat: Very scarce. Found chiefly in the forests along the Godavari.

Uses: The oil of the berries is used in rheumatism. The bark is employed as a demulcent and milk astringent in diarrhœa and dysentery (Dymock).

LIX. LORANTHACEÆ.

276. **Loranthus longiflorus** Desv., *F.B.I.*, V, p. 214.

Vern. Name: *Wajinika* (Tel.).

Habitat: A common parasite on *mohua* (*Bassia latifolia*), ebony (*Diospyros melanoxylon*), *Psidium guyava*, *Melia azadirachta*, *Cordia myxa*, *Anona squamosa*, *Punica granatum*, and other plants.

Other members of this family recorded are:—

277. **Loranthus scurrula** Linn., *F.B.I.*, V, p. 208.

Vern. Name: *Wajinika* (Tel.).

278. **Viscum articulatum** Burm., *F.B.I.*, V, p. 226.

Vern. Name: *Wajinika* (Tel.).

LX. SANTALACEÆ.

279. **Santalum album** Linn., *F.B.I.*, V, p. 231.
(Sandal-wood tree.)

Vern. Names: Sandal, Chandan (Hind.).

Habitat: Found in the Hyderabad forests.

Uses: The heartwood is the well-known sandal wood. It is said to be very cooling, astringent, being useful in fever, heat of the body, thirst, vomiting, biliousness, and gonorrhœa. The wood, ground up with water into a paste, is applied to the temples in fever, to local inflammations, and to skin diseases.

The oil of the wood is a very good remedy for gonorrhœa. The oil from the seed is used in skin diseases.

LXI. EUPHORBIACEÆ.

280. **Euphorbia pulcherrima** Willd., Cooke, *Fl. Bomb. Pres.*, II, Pt. III, p. 570.

Habitat: Native of Mexico. Grown almost everywhere in gardens for its showy floral leaves.

281. **Euphorbia Tirucalli** Linn., *F.B.I.*, V, p. 254. (Milk Bush.)

Vern. Name: Sehnd (Hind.).

Habitat: Abundant on roadsides in villages throughout the Dominions.

Uses: The fresh juice is said to be an effectual application for removing warts, and in rheumatic pains. It has also a great repute as an antisyphilitic.

282. **Euphorbia heterophylla** Linn., Cooke, *Fl. Bomb. Pres.*, II, Pt. III, p. 571.

Habitat: A native of N. America. Cultivated in gardens as an ornamental plant, also found as an escape.

283. **Phyllanthus Emblica** Linn., *F.B.I.*, V, p. 289.

Vern. Names: *Aonla* (Hind.); *Ambliy* (Arab.); *Amelah* (Pers.); *Anvala* (Mar.).

Habitat: Cultivated in gardens for its fruit; also wild in Mulug and Pakhal forests.

Uses: Preserved fruits are tasty, and are considered cooling, laxative, and tonic. The fresh juice is cooling, refrigerant, diuretic, and laxative. The exudation from the incisions on the fruit is used as an external application in the inflammation of the eye (Dutt, *cf.* Kirtikar). Dried fruits possess a slightly aromatic odour and an acidulous astringent taste. These are used in the process of tanning and are an excellent astringent in bowel complaints. The bark is likewise an astringent, and the fresh juice seems to be used in gonorrhœa.

284. **Phyllanthus distichus** Muell., *F.B.I.*, V, p. 394.

Vern. Name: *Herfareuri* (Hind.).

Habitat: Cultivated everywhere in gardens for its fruit.

Uses: The acid and astringent fruit is curried, ripe fruits are eaten raw. The root is an active purgative, and the seed is

also cathartic. The curried fruits are supposed to prevent excess of bile.

285. **Phyllanthus Niruri** Linn., *F.B.I.*, V, p. 298.

Habitat: Grows wild.

286. **Jatropha glandulifera** Roxb., *F.B.I.*, V, p. 382.

Vern. Names: *Jangli-erandi* (Hind.).

Habitat: Very abundant in villages all over, growing in certain areas amongst cactus.

Uses: The oil of the seeds is considered a stimulant application in rheumatism and paralysis, and is also used as an application to ulcers, bad wounds, ringworm, etc. It possesses purgative properties. The root brayed with water is given to children suffering from abdominal enlargements (Kirtikar). The juice of the plant is said to remove films from the eyes (Dymock).

287. **Croton Tiglium** Linn., *F.B.I.*, V, p. 393.

Vern. Names: *Jamal Goṭa* (Hind. and Mar.); *Nepala vitna* (Tel.).

Habitat: Common in forests on the Telangana side.

Uses: The seeds are a very strong purgative. Both the seeds and the oil are useful in many diseases.

288. **Acalypha indica** Linn., *F.B.I.*, V, p. 416.

Vern. Names: *Kuppi* (Hind.); *Khokli* (Mar.); *Kuppai-chettu* (Tel.).

Habitat: Very wild throughout the Dominions, occurring as a weed in gardens, fields, and roadsides.

Uses: It is expectorant, diuretic, purgative, and anthelminthic. The juice of the leaves is put into the ear for earache, it is used with oil as an external application in rheumatism, in scabies and also in snake and centipede-bites. The root is used as a purgative. There are many other properties ascribed to the root and leaves of this useful herb. (For detailed information, refer to Kirtikar.)

289. **Acalypha marginata** Spreng., Cooke, *Fl. Bomb. Pres.*, II, Pt. III, p. 612.

Habitat: A very common foliage plant in gardens.

290. **Mallotus philippinensis** Muell., *F.B.I.*, V, p. 442.

Vern. Names: *Sendur, Kamela* (Hind.); *Chindra sinduri* (Tel.); *Shindur* (Mar.).

Habitat: Common throughout in the forests and hilly regions.

Uses: The red powder covering the ripe capsules furnishes a valuable dye which is employed in dyeing silk. The powder prepared from the fruit possesses vermifuge, anthelminthic, purgative, and cathartic properties.

291. **Ricinus communis** Linn., *F.B.I.*, V, p. 457.
(The Castor-oil Plant.)

Vern. Names: *Arand, Erandi* (Hind.).

Habitat: Cultivated extensively throughout the Dominions, especially on the Marhatwari side.

Uses: The oil from the seeds is used for burning, and as a purgative. It is a good lubricant.

LXII. URTICACEÆ.

292. **Morus indica** Linn., *F.B.I.*, V, p. 492. (Mulberry.)

Vern. Names: *Shahtūt* or *Tūt* (Urdu and Hind.); *Kambali* (Tel.).

Habitat: Mostly grown in gardens.

Uses: Ripe fruits are very tasty and edible. The tree is largely cultivated in Bengal to feed silkworms. Rearing of silkworms on mulberry tree is being experimented in the State by interested and enthusiastic persons.

293. **Ficus bengalensis** Linn., *F.B.I.*, V, p. 499.
(The Banyan.)

Vern. Names: *Bur, Burgat* (Urdu and Hind.); *Pedda-marri* (Tel.).

Habitat: Practically all over the Dominions.

Uses: In certain areas this tree is being worshipped by a certain class of Hindus. In some parts of India, especially Northern India, the latex is used for eye-sore. The milky juice is externally applied for pains and bruises and in rheumatism and lumbago. Considered as a valuable application to the soles of the feet when cracked or inflamed and is also applied to the teeth and gums as a remedy for toothache (Kirtikar).

An infusion of the bark is said to possess specific properties in the treatment of diabetes. The root-fibres are useful in gonorrhœa.

294. **Ficus religiosa** Linn., *F.B.I.*, V, p. 513. (Peepul tree.)

Vern. Names: *Peepul* (Hind.); *Ragi* (Tel.).

Habitat: Very common throughout the Dominions. Usually planted in villages, in avenues on roadsides, near temples, etc., grows as an epiphyte on palmyra and date-palms, also in the crevices of old walls and wells. Under such situations they remain in a stunted condition.

Uses: The bark is astringent, used in gonorrhœa. The fruit helps in digestion and is laxative. The seeds are cooling. In Northern India lac insects are reared on the twigs of peepul for the production of lac.

295. **Ficus glomerata** Roxb., *F.B.I.*, V, p. 535.

Vern. Names: *Gular* (Hind.); *Medi* (Tel.).

Habitat: Very common near villages, planted in avenues on roadsides, grows at its best near water, viz. on the bank of rivers, etc.

Uses: Flavour insipid; much eaten by the poor classes; usually infested with insects. A jelly is made out of the fruits, and is supposed to have a cooling effect. Leaves, bark, roots, and fruit are of medicinal importance, usually made use of by the Indian physicians. The bark is used for washing wounds, and is astringent. It is also employed to remove the poison from wounds made by a tiger or cat. The root is efficacious in dysentery. The fruits are astringent, stomachic and carminative. The milky juice is useful for piles and gonorrhœa, the juice of the fresh and ripe fruits being useful in diabetes and other urinary diseases.

296. **Ficus Carica** Linn., Cooke, *Fl. Bomb. Pres.*, II, Pt. IV, p. 655. (The fig.)

Vern. Name: *Anjir* (Hind.).

Habitat: Frequently cultivated in gardens for its fruit, but never found wild.

Uses: Fruit very much relished.

297. **Ficus elastica** Roxb., *F.B.I.*, V, p. 508. (Indian Rubber tree.)

Vern. Name: Rubber-ka-jhar (Hind.).

Habitat: Grown in a few big gardens in Hyderabad proper and in the districts as an ornamental tree. An interesting feature about it is the development of buttress-roots at the base of the stem radiating in all directions. They are often several feet deep, but not thick.

Uses: The coagulated and dried latex form the India rubber of commerce. Incisions are made on the main stem. Below the incisions pots are tied round the tree, one underneath the other, and left attached for the day. Then they are taken out, and to the milk a little watery solution of alum is added. The milk coagulates and the rubber is allowed to dry and drain for a week or so. (For details, refer to Watt, *The Commercial Products of India.*)

298. **Ficus infectoria** Roxb., *F.B.I.*, V, p. 515.

Vern. Names: *Pipli* (Hind.); *Jive, Juvi, Banda-jivi* (Tel.).

Uses: The bark of this along with the barks of other species is used as a wash for ulcers.

299. **Ficus hispida** Linn., *F.B.I.*, V, p. 522.

Vern. Names: *Kat-gularia, Lumbar* (Hind.); *Boma-medi* (Tel.).

Uses: According to Sanskrit writers, the figs of this plant promote the secretion of milk (Kirtikar).

300. **Artocarpus integrifolia** Linn., *F.B.I.*, V, p. 541. (The Jack-fruit tree.)

Vern. Names: *Phannas* (Hind.); *Panasa* (Tel.).

Habitat: Grown in gardens for its fruit. It has a strong and sweet odour.

Uses: The fruit is delicious but not wholesome, very nutritive but difficult to digest. The root is used internally in diarrhœa. The juice of the plant is applied externally to glandular swellings and abscesses. The leaves are an antidote to snake-poison; also used in skin diseases.

301. **Artocarpus incisa** Linn., Cooke, *Fl. Bomb. Pres.*, II, Pt. IV, p. 658. (Bread-fruit tree.)

Habitat: It is a native of Pacific Islands, and is common at Hyderabad.

302. **Cannabis sativa** Linn., *F.B.I.*, V, p. 487. (Hemp.)

Vern. Names: *Charas, Bhāng, Gānjā* (Hind.); *Ganjari-chettu, Ganjah* (Tel.).

Habitat: Cultivation of this plant is restricted by special regulations, owing to its narcotic properties.

Uses: *Charas*, the narcotic resinous substance, which appears on the stems and inflorescence collected chiefly from

cultivated female plants, is smoked as an intoxicant (often after mixing it with tobacco). *Bhāng* consists of the dried leaves and flowers. Along with almonds, milk, cardimum, sugar, etc., it makes a delicious and intoxicating favourite drink. *Gānjā* is the name given to the dried flowering tops of the cultivated female plants. Both *Bhāng* and *Gāṇjā* are mixed with tobacco and smoked as intoxicants. The male plant yields the fibre. Hemp seeds are edible and a favourite food of the cage-birds.

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Index to the Scientific Names of the Hyderabad Plants

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ARTICLE No. 3.

A Contribution to Angami and Sema Somatology.

By SARABJIT SINGH.

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The Angami and the Sema are two of the main tribes of the heterogenous naked and semi-naked inhabitants of the hilly tract to the south of the Brahmaputra valley in the area generally known as the Naga Hills. Politically they are grouped with a number of other tribes as the Nagas and speak a Tibeto-Burman language of the Assam-Burmese Branch, but neither this political nor the linguistic grouping coincides with the physical features of the different tribes which occupy this area.[1] In the present paper the relationships of these two Naga tribes are discussed so far as they can be deduced by a study of their stature, cephalic and nasal indices.

Our knowledge of the physical characters of the Nagas is very meagre, the only metric data available being those of Waddell,[2] Dixon[3] and Hutton.[4] Unfortunately, however, these data[5] are not sufficient for a detailed analysis, as the number of individuals measured by all these investigators was very small. Dixon includes the Semas under the brachycephalic group in which the Palæalpine (B.H.P.) element is the largest, while the Angamis, according to him, are classed in the dolichocephalic platyrrhine group with a much longer stature.[6] Haddon, on the other hand, found that the dolichocephalic platyrrhine element which is dominant among the Khasis and the Kukis, is weakly represented amongst the Naga tribes, and remarked that 'There is a reason to believe that a Nesiot element (dolichocephalic mesorrhine) is strong among the Naga . . . '[7]. Hutton, who based his conclusion on the presence of frizzly hair amongst the Angamis, opined that there is a Negrito element

[1] Hutton in his monographs, *The Angami Nagas* and *the Sema Nagas*, has fully described the habitat, and the topography of the area in which these peoples reside.

[2] Waddell, 'Tribes of the Brahmaputra Velley'. *Journ. Asiat. Soc. Bengal*, Vol. LXIX, Pt. 3 (1901).

[3] Dixon, in Hutton's *The Angami Nagas*. Appendix I, Part I (1921).

[4] Hutton, *The Angami Nagas* (1921). Appendix I.

[5] Waddell measured only 16 Angamis and 8 Semas; Dixon measured 6 Chakrima Angamis. Hutton measured 21 Chakrima Angamis and 40 Semas; in none of these he has taken their stature.

[6] Dixon, *The Racial History of Man*, p. 261 (1923).

[7] Haddon, *The Races of Man*, p. 116 (1929).

in this tribe.[1] Dudly-Buxton, on the other hand, in his important work on the *Peoples of Asia* asserts that there seems to be no evidence of any Negrito blood on the Eastern Frontier of India.

The data at the disposal of the author are sufficiently representative of the Chakrima group of the Angami and Sema tribes for a somatic study. Each sample consists of 100 adult individuals above 25 years,[2] and may be taken as homogeneous for all practical purposes. Considering the statistical constants of stature, nasal and cephalic indices, the author differs both from Dixon and Haddon in considering the Angamis as a medium statured, mesocephalic and leptorrhine people. The Semas also are mesocephalic with stature below medium and with a mesorrhine nose. In some characters the Sema samples are more variable, specially in reference to the stature and nasal index. The high figure of nasal indices in both the series suggests a higher intermixture in regard to the form of the nose. The variabilities, though sometimes slightly higher than those of other admittedly homogeneous materials, are, however, not significantly different. A table of standard deviations (S.D.) and the coefficient of variation (V.) for stature is given for comparison with an admitted series of homogeneous data.

Series.	*S.D.*	*V.*	
Angami	4·9	2·9	
Sema	6·0	3·7	
Frenchmen	6·47	3·8	*Biometrica,* Vol. I, Vol. I, p. 191 (1901).
English Criminals ..	6·45	3·8	
Germans	6·68	4·0	

The average stature in the case of the Angamis is 165·43 cm. which is above the average of the Asiatic Mongols.[3] The average for the Semas is 160·30 cm. According to Waddell,[4] the average stature of the Angamis is 163·9 and of the Semas 150·1. Hutton did not take any measurements of height in the case of these tribes, apparently because stature is frequently looked upon as the direct expression of economic well-being or the reverse. Within certain limits this is true, but it has not been sufficiently proved that stature is proportionately more variable than certain other accepted characters which are used in the descriptions of racial types.

Head form as expressed in cephalic index shows that among the Angamis 48% are dolichocephalic, 35% mesocephalic and

[1] Hutton, *Man in India,* Vol. VII, pp. 257–262 (1927). 'Although decidedly uncommon among the Angami, Sema . . . tribes instances of even closely curled wooly hair do occur' (p. 258).

[2] The measurements were taken according to the method recommended in the *Lehrbuch der Anthropologie* of Martin and with the Anthropometric set designed by P. Hermann, Zurich.

[3] The Asiatic Mongols range above and below 160 and 161 cm. approximately. (Sullivan—*Anthrop. papers, American Museum of Natural History,* Vol. XXIII, Pt. 1, p. 32 (1918).

[4] Waddell, *Ibid.,* pp. 76, 120.

17% brachycephalic. Among the Semas 17% are dolichocephalic, 46% mesocephalic and 37% brachycephalic. The head in both these series is longer than in the true Negritos[1], the averages being 76·6 (Angami) and 79·3 (Sema). The following table shows the standard deviations of cephalic indices as compared with other admittedly homogeneous stocks :—

Series.	*S.D.* of *C.I.*	*References.*
Angami	4·2	
Sema	3·3	
Bavarian Peasants	3·5	*Biometrica I*, p. 191 (1901).
French Peasants	3·6	
Samoans	3·5	*Mem. B. P. Bishop Museum*, VIII, No. 2 (1921).
Hawaiians	3·6	*Ibid.*, IX, No. 4 (1927).

The differences between the two averages, standard deviations and coefficients of variations are 2·64, 0·82 and 1·3 respectively. Dixon's measurements of the 6 Chakrima Angamis showed an average cephalic index of 77·77. Hutton's average for the Angamis is 76, while that for the Semas is 79. These results do not differ materially from the data given above.

There are serious objections to accepting the nasal index as an expression of the relative proportions of the nose. The measurements of both the nasal height and breadth are very small and even a small error in taking these measurements would seriously affect the averages. Further there is no uniformity on the part of the different observers in determining the upper limits of the nose. The location of the nasion by various observers is never the same and varies to an appreciable extent ; this naturally not only affects the mean for the nasal height but also influences the nasal index. Nevertheless since the index is highly descriptive it is worth while considering it. Hutton records the nasal index of the Angami as 79 and of the Sema as 80[2] as against 89·37 (Angami) 79·75 (Sema)[3] calculated from his own measurements. My averages are 68·93 for the Angami and 70·18 for the Sema. Both my series show a high leptorrhine element with a characteristic absence of the platyrrhine.[4] The lower value of nasal index of both the Angamis and the Semas is a factor which distinguishes them from the Predravidian (*DP*) of Haddon.

Table II (Appendix) shows the results of correlation between the cephalic index and nasal index. In the composition of the Angamis the M.P. (blend of *DP*+*BP* probably) element is only

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[1] The C.I. of the Andamanese is 83 (Haddon), of Negritos of the Philippine Islands 83·3 (Sullivan).

[2] Hutton, *The Angami Nagas, ibid.*

[3] Thanks are due to my statistician friend Mr. S. Sen Gupta who is revising Hutton's calculations, for kindly allowing me to use these figures.

[4] See Appendix for tables.

2%, whereas among the Semas it is 1%. The unblended *BP* and *DP* are also very negligible. The Angamis disclose a dolichocephaly in shape with a small element of brachycephalic type allied to the Burmese. The Semas are mainly mesocephalic, mesorrhine containing a stronger brachycephalic leptorrhine type which Dixon calls Alpine. The small platyrrhine element along with the dolichocephalic and brachycephalic types may be the earlier strata of Negroid and Palæ-Alpine respectively, but from the data available to me it seems that they had very little influence on the racial composition of these people. Dixon in *The Khasi and the Racial History of Assam* [1] regards the *DL* factor as having had no influence in Assam racially except among Syntengs, but my investigations of the Angamis definitely confirm Hutton's [2] surmise that 'the *DL* factor is as strong in their areas as in the Jaintia Hills'.

To test whether these two groups of Nagas may be considered as samples drawn from the same general population or whether they must be considered as statistically divergent, the C^2 test of Prof. Pearson [3] was used. The mean value of C^2 for two groups belonging to the same population is zero with a probable error of $\pm \cdot 67449 \frac{2}{P}$, where P is the total number of characters. Taking the value of P as 7,[4] the probable error of C^2 works out at $\pm 0{\cdot}36$ approximately. The values of the coefficient (C^2) of the Angamis and the Semas which is 26·29, with the probable error $\pm 0{\cdot}36$, therefore, show that these two groups must be considered as being significantly differentiated from each other.

The actual magnitude of the divergence between these two groups may be measured by the coefficient of divergence [5] defined by Prof. P. C. Mahalanobis as

$$D^2 = \left[\frac{1}{P} S \frac{(M_p - M_p{}^1)^2}{\sigma P^2}\right] - \frac{n+n^1}{n \,.\, n'}$$

with a variance given by

$$\Sigma = \frac{4}{P}\left(\frac{n+n'}{n.n'}\right) . \bar{D}^2 + \frac{2}{P}\left(\frac{n+n'}{n \,.\, n'}\right)^2,$$

where M_p and $M^1{}_p$ are the observed mean values of the Pth character in two groups of size n, n'; σP^2 is the reliable value of the variance of Pth character and D^2 is the mean value of

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1 Dixon, *Man in India*, Vol. II (1922).

2 Hutton in the Introduction to W. C. Smith's *Ao Nagas*, pp. xiii–xiv (1925).

3 *Biometrika*, XVIII, pp. 105–107 (1926).

4 Stature, Head length, Head breadth, Nasal height, Nasal breadth, Cephalic index and Nasal index.

5 Mahalanobis, *Journ. Asiat. Soc. Bengal*, Vol. XXVI, p. 580 (1930).

D^2. The D^2 computed in accordance with the above formulæ for the two samples of the Angamis and Semas is 0·663 which again shows that they are definitely divergent. It may, therefore, be concluded that the relationship of the Chakrima Angamis and Semas as suggested by Hutton[1] is not borne out by the author's anthropometric studies.

APPENDIX.

TABLE I.

	Angami $n=100$. Mean.	Standard Deviation.	Variability.	Sema $n=100$. Mean.	Standard Deviation.	Variability.
ture ..	165·43±·33	4·96±·33	2·9±·13	160·38±·40	6·03±·28	3·7±·17
halic Index	76·67±·30	4·20±·21	5·4±·25	79·31±·22	3·38±·15	4·1±·19
al Index ..	68·93±·43	6·53±·31	9·4±·45	71·18±·50	7·51±·35	10·5±·50

n is the number of individuals in each series.

TABLE II.

Grouping of cephalic and nasal indices.

Angami.

	D	M	B
L	29	21	12
m	19	12	5
P	x	2	x

Sema.

	D	M	B
L	11	16	18
m	5	29	17
P	1	1	2

D=Dolichocephalic; M=Mesocephalic; B=Brachycephalic; L=Leptorrhine; m=Mesorrhine; P=Platyrrhine. Ranges are as given in Martin's *Lehrbuch der Anthropologie*, Vol. I, pp. 198, 202 (1928).

[1] Hutton, *The Sema Nagas*, p. 4 (1921).

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ARTICLE NO. 4.

Notes on Some Indian Gall Forming Psyllidæ (*Homoptera*).

By M. S. MANI.

(*Communicated by Dr. Sunder Lal Hora.*)

INTRODUCTION.

Unlike most other groups of gall forming insects it is gratifying to note that the Homopterous family of 'jumping plant-lice' or the Psyllidæ has been somewhat extensively studied in India. Kieffer[1] described numerous species of Psyllids and their galls, mainly from Bengal. Extensive collections of these insects from different parts of India were described by Buckton and Crawford, mostly in the *Indian Museum Notes* and the *Records of the Indian Museum*. Ramakrishna Ayyar[2] also published references to all the species described from India up to 1924. In the same year Sundar Raman[3] listed twenty-four galls of Psyllids and briefly described some. His account was exclusively botanical and inaccurate in several respects. A series of galls really caused by Psyllids on various species of *Terminalia* (Combretaceæ) were incorrectly recorded by him as galls of Hymenoptera, the Chalcid parasites of the Psyllids being mistaken for the primary gall maker. Very recently Rahman[4] described the immature stages of several species of Indian Psyllids.

For several years I have been collecting Psyllids and their galls from different parts of India. In this paper are redescribed several Psyllid galls and I have also included a synoptic key to the species of *Pauropsylla* studied by me.

My thanks are due to Rao Sahib Dr. T. V. Ramakrishna Ayyar, Government Entomologist, Agricultural Research Institute, Coimbatore, for suggesting this work and to Dr. Baini Prashad, Director, Zoological Survey of India, Indian Museum, Calcutta for giving me facilities for work in the laboratories of the Zoological Survey.

1 Kieffer, J. J., *Ann. Soc. Sc. Bruxelles*, XXIX, pp. 159–182, (1905); and *Marcellia*, VII, pp. 159–162, (1908).

2 Ramakrishna Ayyar, T. V., *Rec. Ind. Mus.*, XXVI, pp. 621–625, (1924).

3 Sundar Raman, A. H., *Journ. Ind. Bot. Soc.*, IV, pp. 9–14, (1924).

4 Rahman, Khan A., *Ind. Journ. Agric. Sc.*, II, p. 359, (1932).

SYSTEMATIC.

Subfamily PAUROPSYLLINÆ.

Genus **Pauropsylla** Rubs.

Rubsaamen [1] erected this genus in 1899 for a Psyllid from Sumatra, but his characterisation was incomplete in several respects. In 1905 Kieffer (*loc. cit.*, p. 167) revised the genus, describing two species, *P. ficicola* Kieff. and *P. globuli* Kieff., from India. He summarised the diagnostic characters of this genus as follows : ' Corps lisse. Tête au moins aussi large que le thorax, transversale, deaux fois aussi large que longue, dépourvue de prolongments sur la face. Yeux resortant fortement sous forme d'hémisphères. Vertex à peu près plan, divisé par un sillon médian et longitudinal, et offrant parfois de chaque côté une proéminence hémisphérique et velue sur le côté externe de laquelle se trouve un des ocelles postériurs. Vue de profil, la tête ne se prolonge pas au delà des yeux ; front et face perpendiculaires. Antennes de dix articles, au moins aussi longues que la tête et la thorax réunis, subfiliformes. Thorax convexe, plus élevé que la tête. Ailes hyalines ; les antériures arrondes au bout ou presque tronquées, ayant leur plus grande largeur à l'extrémité ou près de l'extrémité ; partie basale du cubitus plus courte que la nervure intermédiaire, celle-ci beaucoup plus courte que la nervure basale ; nervure discoïdale sortant du cubitus ; stigma nul '.

The following Indian species of this genus are known to be gall forming : *P. ficicola* Kieff., *P. globuli* Kieff., *P. depressa* Craw., *P. tuberculata* Craw., and *P. spondiasae* Craw. The last three species may be distinguished from each other with the help of the key given below ; the other two are easily separated by Kieffer's table. Crawford [2] has tabulated the old world species of this genus.

Partial key to the species.

I. Fore wings hyaline and colourless.
    A. Fore wings rather small, a little less than twice as long as broad .. .. .. *P. tuberculata* Craw.
    B. Fore wings large, a little longer than twice as long as broad .. .. .. *P. depressa* Craw.
II. Fore wings hyaline but tinged yellowish .. *P. spondiasae* Craw.

Pauropsylla tuberculata Craw.

1912. *Pauropsylla tuberculata*, Crawford, *Rec. Ind. Mus.*, VII, p. 430.

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1 Rubsaamen, E. H., *Entomol. Nachr. Berlin.*, XXV, p. 262, (1899).
2 Crawford, D. L., *Philip. Journ. Sc.*, XV, p. 142, (1919).

1924. *Pauropsylla tuberculata*, Ramakrishna, *Rec. Ind. Mus.*, XXVI, p. 622.
1932. *Pauropsylla tuberculata*, Rahman, *Ind. Journ. Agric. Sc.*, II, p. 359.

This is a dark reddish brown species, measuring about 2 mm. long. It gives rise to small, barrel-shaped, hard, sub-lignose galls on the leaves of *Alstonia scholaris* Linn. Rahman has briefly described and figured the galls. The species falls between *P. floccosa* Craw. and *P. triozoptera* Craw. in Crawford's tables.

Distribution.—Bombay, Bengal, Madras ; probably throughout India.

Pauropsylla depressa Craw.

1912. *Pauropsylla depressa*, Crawford, *Rec. Ind. Mus.*, VII, p. 429
1924. *Pauropsylla depressa*, Ramakrishna, *Rec. Ind. Mus.*, XXVI, p. 622.
1932. *Pauropsylla depressa*, Rahman, *Ind. Journ. Agric. Sc.*, II, p. 359.

This species is somewhat larger than *P. tuberculata* Craw., from which it is further distinguished by its lighter colour, tinged with orange red. Marginal cells in the fore wings are nearly equal. This species runs with *P. udei* Rubs. in Crawford's tables.

This species attacks the leaves of *Ficus glomerata* Roxb. and gives rise to large, globose galls. The Psyllid giving rise to galls on shoot of Cinnamon at Mangalore is believed by Crawford to be identical with this species, which however needs confirmation.

The gall (Plate 1, fig. 1) has been incompletely described by Sundar Raman (*loc. cit.*, p. 10) and Rahman ; I give below a complete description :—

5–10 mm. in diameter, regular, simple, globose or obpyriform, sessile, perfoliate, unilocular ; or 15–30 mm. in diameter, irregular, compound, multilocular, with large, spherical or convex tubercles ; the tubercles representing the several simple galls which have incompletely fused into the compound mass due to forming very close to each other ; yellowish, orange, reddish or reddish brown, almost entirely devoid of chlorophyll, very conspicuous against the background of dark green foliage, glabrous or reticulate with the prominently raised veins or dotted with small dark red scales ; generally thick walled and almost solid, carnose, sometimes less so ; dehiscent when old by lacerated openings on the under side, which let out the adult Psyllid.

The following structure is made out in a transverse section : The epidermis encloses a broad annular strip of undifferentiated parenchyma, which surrounds the central hollow space. Concentric, broken, irregular, circles of proliferating cells occur in the annular parenchyma. Numerous veins are scattered superficially

and deeply in the parenchyma. There is no trace of the palisade or spongy tissue of the leaf, both having completely degenerated into the simple undifferentiated parenchyma. In some young specimens a small fistular opening is found on the under side of the gall, while in the older galls this passage closes more or less completely due to cell proliferation. The galls are really the invaginated and swollen leaf. The seat of cell proliferation is the parenchyma of the leaf.

Distribution.—Throughout India, Burma, Ceylon, Java, Hongkong, and the Philippines. In India the galls are most abundant during the time of the monsoon rains.

Several examples in formalin in the collections of the Zoological Survey of India, (Ind. Mus.), Calcutta. Coll. M. S. Mani, St. Paul's High School Garden, Madras, 4-xii-1929 and Tanjore Bragadisvar Temple Garden, Tanjore, Madras Presidency.

Pauropsylla spondiasae Craw.

1915. *Pauropsylla spondiasae*, Crawford, *Philip. Journ. Sc.*, X, p. 260.
1924. *Pauropsylla spondiasae*, Ramakrishna, *Rec. Ind. Mus.*, XXVI, p. 622.

This species produces peculiar scroll-like galls on leaves of *Spondias mangifera* Linn.

Distribution.—Throughout Ceylon and the Madras Presidency.

Phacopteron lentiginosum Buckt.

1894. *Phacopteron lentiginosum*, Buckton, *Ind. Mus. Notes*, III, p. 18.
1912. *Phacopteron lentiginosum*, Crawford, *Rec. Ind. Mus.*, VII, pp. 420-421.
1919. *Phacopteron lentiginosum*, Ramakrishna, *Rep. Third Entomol. Meeting, Pusa*, p. 1030.
1924. *Phacopteron lentiginosum*, Crawford, *Rec. Ind. Mus.*, XXVI, p. 615.
1924. *Phacopteron lentiginosum*, Ramakrishna, *Rec. Ind. Mus.*, XXVI, p. 622.

This conspicuous species was described by Buckton from Poona and later redescribed by Crawford. The nymph of this species is not flattened as in the rest of the Psyllids but large and robust. It gives rise to very remarkable galls on leaves of *Garuga pinnata*. The galls have been very briefly described by Sundar Raman (*loc. cit.*, p. 12) and Ramakrishna Ayyar.

I give below a complete description of the gall:—

20 mm. long, 10 mm. in diameter, regular, simple, ovoid, obovoid, globose or subcylindrical, ventricose, or sometimes compressed, free, cavate, unilocular, acystiferous, indehiscent local swellings; sessile, sometimes with a very short, narrow neck-like stalk; two to six, rising from the middle of a cupiform

tumescence, near the mid rib, towards the base of, and generally on the upper surface of the leaf. Yellow or yellowish green and tinged with brown or reddish brown ; glabrous, with about a dozen, longitudinal, prominently raised, green, strong nerves, radiating from a point on the top ; the nerves anastomosing with each other and freely giving off reticulating branches below ; moderately hard and brittle ; the cavity is very large and contains generally from one to two nymphs of the Psyllid. Really the galls are the invaginated and swollen leaves. The eggs are laid on the lower surface of the leaf near the mid rib. A slight local tumescence accompanies the irritation produced by the nymphs hatching from these eggs. Subsequent invagination on the under side and further cell proliferation result finally in the formation of the gall. Unlike in most galls of Psyllids the mouth of the invaginated cavity closes very soon due to rapid cell proliferation of the surrounding tissues, and its position is only indicated by a minute pit. Transverse section of the gall is an annular strip of simple parenchymatous cells, with a well developed epidermis on the outer side and a few layers of dead cells on the inner side in the case of the older galls. Numerous veins and groups of vascular bundles are scattered irregularly in the parenchyma. The palisade and the spongy parenchymæ of the leaf are more or less degenerated.

Subfamily CARSIDARINÆ.

Dinopsylla grandis Craw.

1924. *Dinopsylla grandis*, Crawford, *Rec. Ind. Mus.*, XXVI, p. 619.
1924. *Dinopsylla grandis*, Ramakrishna, *Rec. Ind. Mus.*, XXVI, p. 623.

This species was described by Crawford from a series of Psyllids bred by Ramakrishna Ayyar from hairy galls on leaves of *Ficus nervosa*. It has also been recorded from Brazil by Crawford. In 1919 Ramakrishna Ayyar [1] described the remarkable galls produced by this species from Taliparamba Forest in North Malabar. I collected the galls and the Psyllid in the Walayar Forest, South Malabar and from this it would appear that the species is widely distributed in South India. I add the following note to the record of Ramakrishna Ayyar :—

15 mm. in diameter, regular, simple, globose, rarely subfusiform ; carnose, local, free, sessile excrescences generally on or near the mid rib or some of the larger veins of the leaves ; pale yellowish green and densely covered with long, thin, light brownish coloured villous hairs ; unilocular and looking like a hairy ball on the upper surface of the leaf. A few vascular

[1] Ramakrishna Ayyar, T. V., *Rep. Proc. Third Entomol. Meeting, Pusa*, p. 1031, (1919).

bundles are irregularly scattered in an undifferentiated parenchymatous tissue. The parenchyma surrounds a large central cavity. The outermost layer of cells of the parenchyma develop into the villous hairs.

Subfamily TRIOZINÆ.

Trioza fletcheri Craw.

1912. *Trioza fletcheri*, Crawford, *Rec. Ind. Mus.*, VII, p. 434.
1924. *Trioza fletcheri*, Ramakrishna, *Rec. Ind. Mus.*, XXVI, p. 624.

This species was originally described by Crawford from specimens taken by Fletcher on *Gmellina arborea* at Pusa and was later recorded from the peculiar galls on leaves of *Trewia nudiflora* by Ramakrishna Ayyar. I have collected the species and its galls from Coimbatore, Vellore, and Calcutta. From the material collected at Sibpore near Calcutta I bred numerous Chalcid parasites, some of which were doubtless true primary parasites on the nymphs of this species, though it is likely that the rest are hyperparasites. Galls of this species are abundant throughout the year in Calcutta. Sundar Raman and Rahman (*loc. cit.*) have figured the galls and the immature stages of this species.

Megatrioza vitiensis (Kirkaldy).

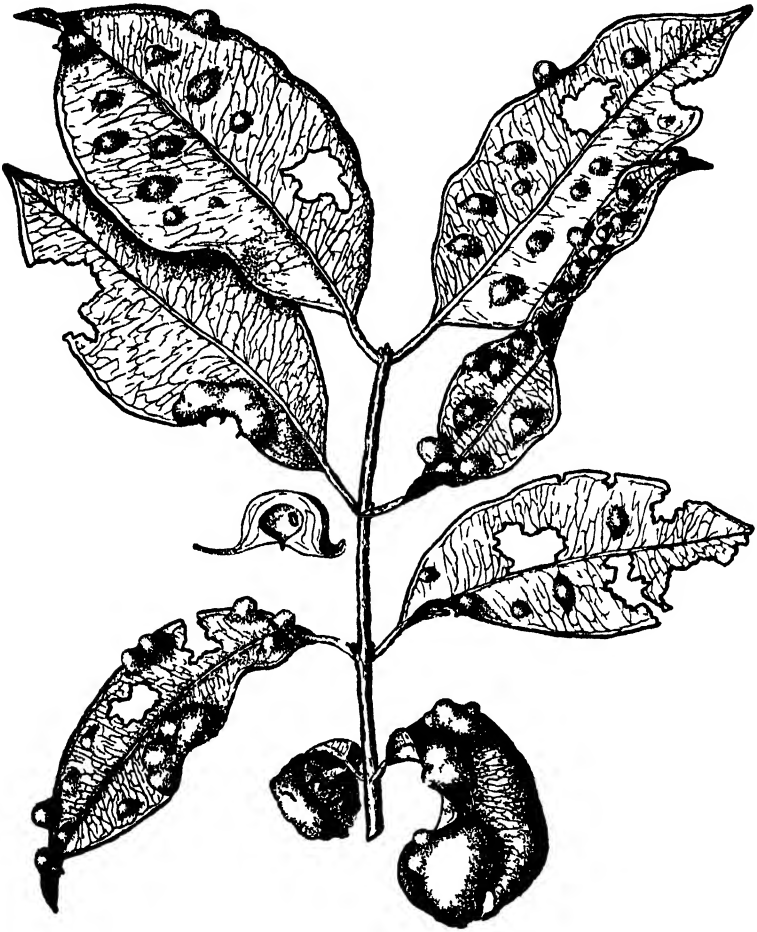
1907. *Trioza vitiensis*, Kirkaldy, *Proc. Hawaiian Entomol. Soc.*, I, p. 103.
1915. *Trioza eugeniæ*, Crawford, *Philip. Journ. Sc.*, X, p. 265.
1919. *Megatrioza vitiensis*, Crawford, *Philip. Journ. Sc.*, XV, p. 195.
1924. *Megatrioza vitiensis*, Ramakrishna, *Rec. Ind. Mus.*, XXVI, p. 624.

This widely distributed species has been recorded making galls on *Eugenia malaccaensis* in several Pacific Islands, Strait Settlements and Ceylon. I have bred this species from the pustuloid gall on the leaves of *Eugenia jambolana* (DC.) taken in different parts of India. Sundar Raman's (*loc. cit.*, p. 13) brief description of the gall, which he recorded as produced by an unknown Psyllid, is inaccurate in several respects. I give below full description of the gall. (See Text-fig. on p. 105.)

There are two varieties of the gall: simple and compound.

Simple variety.—5-10 mm. in diameter, regular, pustuloid, hemispherical, subpyriform, subovoid, rarely subglobose; sessile, glabrous, greenish yellow and tinged with pinkish or brownish red; somewhat hard and brittle, rarely fleshy and soft, turning woody and brown when old and dry; moderately thick-walled, unilocular; the cavity large, irregular, containing a single nymph of the Psyllid, sometimes having a minute fistular passage opening to the outside on the under side of the gall; generally very

conspicuous on the upper side of the leaves, dehiscing by irregular slit-like cracks when old. Shape and size of the leaves on which this kind of gall forms are not much affected



Text fig. Pustuloid galls of *Megatrioza vitiensis* (Kirkaldy) on leaves of *Eugenia jambolana* (DC.). (⅓ Natural size.)

Compound variety—This variety results from a more or less complete fusion of numerous galls of the simple kind crowding together.

10-25 mm. in diameter, irregular, extensive, sometimes involving an entire leaf, with diffuse, large, globose tubercles,

which represent the simple galls which have fused into one mass; sometimes without such tubercles; sessile, glabrous, whitish or yellowish white, occasionally tinged with red or violet; solid, fleshy, multilocular; each cavity small and with one nymph of the Psyllid. The gall is very much arched on upper side and deeply excavated on the under side which further has irregular lacunæ dehiscing by irregular lacerated cracks. Leaves bearing this variety of galls are very badly deformed and undersized.

The compound variety of the gall is much less common than the simple one. It differs from the simple type in its larger size, irregularity of form, paler colour, and numerous cavities. (See Text-fig. on p. 105.)

The gall first appears as a minute, yellowish green, hard, verrucose structure on the leaf surface, formed by the invagination of the leaf on the under side, cell proliferation and consequent tumescence. A rather slow cell proliferation and growth finally result in the fully formed gall. The palisade and spongy parenchymæ of the leaf are completely degenerated into the undifferentiated parenchyma of the gall. The parenchyma of the gall is seen to be made of large, hexagonal or round cells and is irregular and large. The epidermis is normal. Veins of the leaves entering the gall are scattered irregularly deep in the flesh of the gall, which appear in longitudinal sections in the form of an arch; thus demonstrating the early invagination of the leaf on the under side.

When old the galls dehisce as a result of the slow drying by irregular lacerated cracks and thus the full grown last instar nymph escapes to the outside. The stimulus of the outside air appears to bring about the final emergence of the adult Psyllid from the nymph. A fruit fly (*Trypetid*) breeds in the succulent flesh of the galls of the compound variety. Larvæ of an unknown Lepidoptera and Curculionid beetle were observed to be boring into the flesh of the gall. A Chalcid parasite has been bred from the nymph of the Psyllid from this gall.

Several examples in formalin in the collections of the Zoological Survey of India (Ind. Mus.), Calcutta. Coll. M. S. Mani, a scrub jungle near Tanjore, Madras Presidency, 30-xii-1928.

Megatrioza hirsuta (Craw.).

1912. *Kuwayama hirsuta*, Crawford, *Rec. Ind. Mus.*, VII, p. 427.
1919. *Megatrioza hirsuta*, Crawford, *Philip. Journ. Sc.*, XV, p. 201.
1924. *Megatrioza hirsuta*, Crawford, *Rec. Ind. Mus.*, XXVI, p. 621.
1924. *Megatrioza hirsuta*, Ramakrishna, *Rec. Ind. Mus.*, XXVI, p. 625.

This species was first provisionally referred by Crawford to the genus *Kuwayama* from material taken in the Bombay Presi-

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SCIENCE

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NOTICE

His Majesty, the King Emperor, has been graciously pleased to grant permission to the Asiatic Society of Bengal to use the title 'Royal' before its name.

The Society, therefore, will henceforth be known as the 'Royal Asiatic Society of Bengal', and the *Journal* and *Year-Book* will be called *Journal of the Royal Asiatic Society of Bengal* and *Year-Book of the Royal Asiatic Society of Bengal*, and the abbreviations for references will be: JRASBL, JRASBSc, and YBRASB.

JOHAN VAN MANEN,
General Secretary,
Royal Asiatic Society of Bengal.

CALCUTTA,
1, PARK STREET,
November, 1936.

Journal Royal Asiatic Society of Bengal. Science. B R
Volume II, 1936.

Article No. 1.

The anatomy of *Otolithus ruber* (Bl. & Schn.) Part I. The Endoskeleton.[1]

By M. Dharmarajan.

Contents.

[1] From the University Zoological Laboratory, Madras.

INTRODUCTION.

No suitable text-book dealing with a type Teleostean Fish is available for students studying Zoology in South India. It is to supply such a demand that this work was taken up. The Endoskeleton of *Otolithus ruber* (Sciaenidæ) is described in this part, while the anatomy of the soft parts will be dealt with later.

Otolithus ruber is selected as a type, for it is a very common, edible, Sciaenid fish found along the Coromandel Coast throughout its length. It grows to about two feet in length and is found in large numbers during the South-West Monsoon months—June to October.

The present investigation was carried out in the University Zoological Laboratory, Madras, under the guidance of Prof. R. Gopala Aiyar, the Director. I am deeply indebted to him for constant help and encouragement and also to Dr. S. L. Hora and Dr. H. S. Rao for going through the manuscript and offering valuable suggestions. I have also to thank the Madras University for the award of a Research Studentship which enabled me to carry on this work.

ENDOSKELETON.

1. Axial Skeleton.

(A) *Head Skeleton.*

The complete skeleton of the head of *Otolithus ruber* is wedge-shaped with the point of the wedge directed anteriorly. Looked at from the side, it presents a definite triangular outline. It is widest near its posterior end (the auditory region) and its length is about twice the maximum width.

The large opercular bones are very prominent and their straight ventral edges form more than one half of the ventral edge of the whole head skeleton.

In a lateral view, the greatest height of the skeleton is at the region of the pre-operculum and this is about two and a half times the height of the skull proper in this region. 'The skull includes those bones and cartilages of the head that are immoveably attached together, to form, in their posterior portion, the brain case ; in their anterior portion the ant-orbital process and the rostrum.' (**3***).

The bones of the skull are well ossified and hard. Many of them contain, in small crevices, plenty of fatty matter.

* Numerals in bold type in brackets refer to the number of references in the *Bibliography* at the end of the paper.

Large muciferous cavities and canals are developed on the dorsal surface of many of the skull bones.

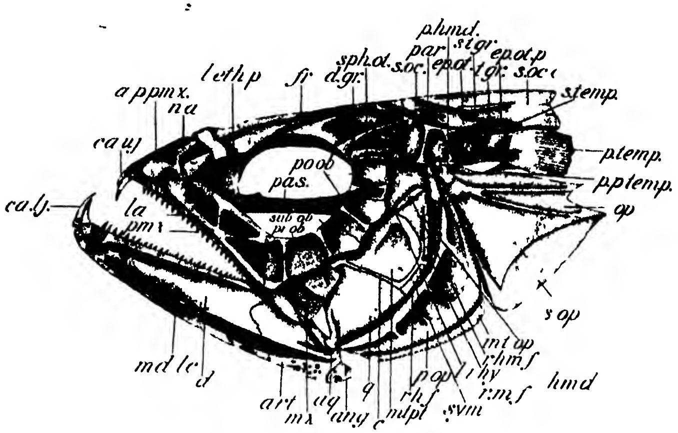

FIG. 1. Side view of the Head Skeleton (×2⅗).

ang., angular ; *a.p.pmx.*, ascending process of premaxilla ; *a.q.*, articulatory head of quadrate ; *art.*, articular ; *c.*, cartilage ; *ca.l.j.*, canine of the lower jaw ; *ca.u.j.*, canine of the upper jaw ; *d.*, dentary ; *d.gr.*, dilatator groove ; *ep.ot.*, epi-otic ; *ep.ot.p.*, epi-otic process ; *fr.*, frontal ; *hmd.*, hyomandibular ; *int.op.*, inter-operculum ; *la.*, lachrymal ; *l.eth.p.*, lateral ethmoidal process ; *l.i.hy.*, foramen for ligament from interhyal to sphenotic ; *md.l.c.* mandibular lateral line canal ; *mt.pt.*, meta-pterygoid ; *mx.*, maxilla ; *na.*, nasal ; *op.*, operculum ; *par.*, parietal ; *pas.*, parasphenoid ; *p.hmd.*, posterior articulatory process of hyomandibular ; *p.mx.*, premaxilla ; *po.ob.*, post-orbitals ; *p.op.*, pre-operculum ; *p.p.temp.*, process of post-temporal uniting with opisthotic ; *pr.ob.*, pre-orbital ; *p.temp.*, post-temporal ; *q.*, quadrate ; *r.h.f.*, foramen for ramus hyoideus facialis ; *r.hm.f.*, foramen for ramus hyomandibularis facialis ; *r.m.f.*, foramen for ramus mandibularis facialis ; *s.oc.*, supra-occipital ; *s.oc.c.*, supra-occipital crest ; *s.op.*, sub-opercular ; *sph.ot.*, sphenotic ; *s.temp.*, supra-temporal ; *s.t.gr.*, supra-temporal groove ; *sub.ob.*, sub-orbital ; *sym.*, symplectic ; *t.gr.*, temporal groove.

(*a*) SKULL PROPER.

The skull proper of *Otolithus ruber* is about two and a half times as long as it is broad and its maximum breadth is nearly twice the depth at its extreme hind end. The mid-ventral line of the skull, unlike that of *Scomber* (**3**), is perfectly straight and, therefore, its hind end forms the deepest part of the skull. The anterior end (ethmoid region) of the skull is quite narrow, and the breadth increases gradually upto the post-orbital region. Beyond this the breadth is quite the same till the posterior end, only the pterotic processes of the two sides divaricating outwards. Thus behind the orbital region, the lateral edges of the skull are very nearly straight. The mid-dorsal line

of the skull is not quite straight, the posterior half being at a higher level. The ethmoidal region is at a lower level than the frontals, so that the mid-dorsal line bends down here.

The dorsal surface of the skull is not flat. In the orbital region the lateral half of each frontal is arched upwards to accommodate the eye-ball. The frontal here shows a definite convexity. Between the two convexities of the two frontals the surface is quite flat.

From the posterior mesial corner of each frontal there arises a shallow groove, the dilatator groove (*d.gr.*), which runs outwards over the dorsal part of the sphenotic and then backwards over the pterotic and terminates at the end of that bone.

There are two more grooves, shallower than the dilatator and arising from the same point. The more lateral of the two, the temporal groove (*t.gr.*), is situated mesial to the dilatator groove, and consists of two portions, an anterior portion traversing a part of each frontal, parietal and pterotic, and a posterior portion very much depressed and opening out at the hind end of the skull. At the anterior mesial corner of the posterior portion of the depression is a cavity directed forwards and mesially. Into the posterior portion of the groove extend the trunk muscles.

The third groove which is mesial in position and situated internal to the temporal is the supra-temporal groove (*s.t.gr.*). It is much shallower than the others. Anteriorly it bends out slightly laterally, and the two supra-temporal grooves are separated by the median supra-occipital crest. Ventral to the posterior end of the groove there is on the mesial part of the posterior surface of the skull, a highly depressed portion which terminates behind at the base of the ex-occipital facets. The supra-temporal groove as a whole is very faint.

Behind the orbital region the skull is dome-shaped. The extreme posterior ends of the frontals contribute partly to the formation of this dome.

The posterior part of the skull, namely, the occipital region, is at a lower level than the auditory part. The anterior half of the auditory region is accommodated in the dome while posteriorly there is a sudden fall to a lower level.

The posterior end of the skull which is rather small and constricted in appearance, bears the large concavity of the basi-occipital, the two flat ex-occipital facets and the foramen magnum.

The original chondrocranium is completely ossified, and there is little or no cartilaginous remnant in the adult except the rostral. All the bones are suturally connected with one another and their boundaries are fairly visible in the prepared skull. The sutural connections are formed in many cases by the interlocking of splint-like processes arising from the bones.

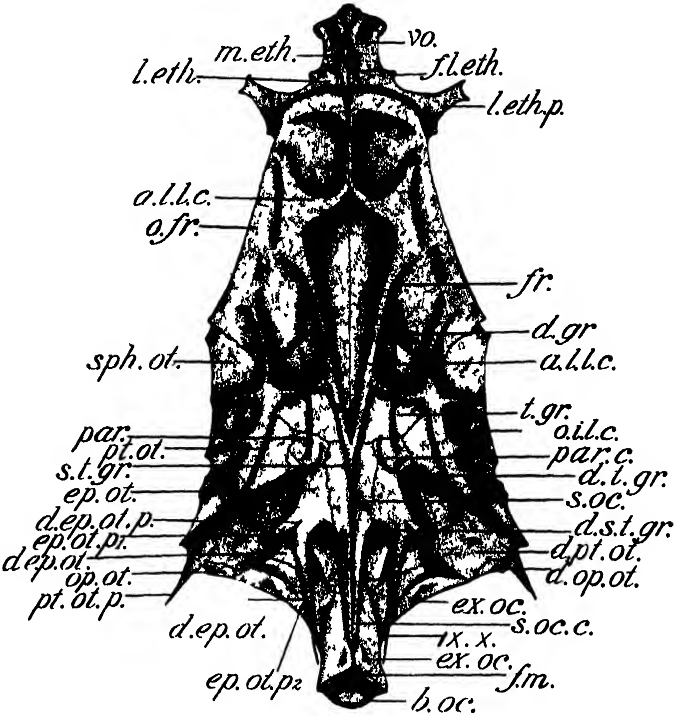

FIG. 2. Dorsal view of the Skull (× 1¼).

a.l.l.c., arch over lateral line canal; *b oc.*, basi-occipital; *d ep ot.*, depressed part of opi-otic; *d.ep.ot p*, depression on epi-otic for lodgement of post-temporal process; *d.gr.*, dilatator groove; *d op.ot.*, depression on opisthotic for lodgement of post temporal process; *d.pt.ot*, depressed part of pterotic; *d.s.t.gr.*, depressed part of supra-temporal groove; *d.t gr.*, depressed part of temporal groove; *ep ot*, epi-otic, *ep ot.p1.*, epi-otic process (short); *ep ot p2.*, epi-otic process (long); *ex.oc.*, ex-occipital; *f l.eth.*, facet on lateral ethmoid for palatinal articulation; *f.m.*, foramen magnum; *fr.*, frontal; *l.eth*, lateral ethmoid; *l.eth.p*. lateral ethmoidal process; *m.eth*, mesethmoid; *o.i.l.c*, otic section of infra orbital lateral line canal; *o.fr.*, orbital elevation of frontal; *op.ot.*, opisthotic; *par.*, parietal; *par.c.*, parietal crest; *pt.ot.*, pterotic; *pt.ot.p.*, pterotic process; *s.oc.*, supra-occipital; *s oc.c*, supra-occipital crest; *sph.ot.*, sphenotic; *s.t.gr.*, supra-temporal groove; *t.gr.*, temporal groove; *vo*, vomer; *ix, x.*, foramen for glossopharyngeal and vagus nerves.

The skull can be easily divided into: (1) An anterior ethmoidal or nasal region; (2) an orbito-temporal region; (3) the otic or auditory region and (4) the posterior occipital region which articulates with the vertebral column behind.

1. *Ethmoidal Region.*

This is the anteriormost region of the skull situated in front of and on a lower level than the frontals. This part comprises the following bones: the mes-ethmoid, the lateral or ect-ethmoids, the nasals, the vomer and the rostral.

Mes-ethmoid: (*m.eth.*). The mes-ethmoid is a small median, elongated bone with slight lateral projections and a flat, oval base. Mid-dorsally, from its middle portion arises an upwardly directed vertical process which goes to meet the anterior end of the frontal region. Thus, the portion of the mes-ethmoid posterior to the above process is tucked in beneath the frontals. The process is also continued as a faint ridge upto the anterior end of the bone. Ventrally, the anterior half of the bone is solid, while the posterior half is scooped out to form a concavity. This concavity is the dorsal half of the mes-ethmoidal cavity (45) and the posterior half of the mesethmoid forms its roof. The two lateral edges of the mesethmoid possess splint-like processes which effect a sutural connection with the lateral ethmoids. The mesethmoid is bounded laterally by the ect-ethmoids, posteriorly by the frontals, ventrally by the mes-ethmoidal cavity and beneath it by the vomer, while the rostral is situated dorsal to it. The anterior end of the mes-ethmoid bends down and unites with the anterior end of the vomer.

Lateral or Ect-ethmoid: (*l.eth.*). This paired bone which occurs one on either side of the mesethmoid, is of an irregular shape. Anteriorly it is short and stout and forms the main body of the bone. From this part arise two large, leaf-like posterior processes and a triangular postero-lateral process. The former processes unite ventrally with the frontals and the latter process (*l.eth.p.*) is directed outwards to form the anterior boundary of the orbit. This is well-ossified and is the so-called Prefrontal bone. Just where the three processes arise from the body of the bone, there is a deep dorsal concavity (the floor of the nasal cavity) which bears the foramen for the olfactory nerve.

Antero-dorsally from the body of the bone, at the base of the anterior edge of the lateral process, there arises a small process bearing a flat facet (*f.l.eth.*) at its tip. This facet is directed forwards and upwards and glides over a similar ill-defined facet at the dorsal anterior end of the palatine.

Antero-ventrally, from the inner or mesial edge of the bone arises a large downwardly and backwardly directed process. At the base of this process is a ventral, tiny, ball-like knob (*k.l.eth.*) which fits into a corresponding socket at the anterior end of the palatine. The process itself is suturally united with the anterior end of the parasphenoid by means of splint-like processes.

The anterior extremity of the frontal lies over the posterior

part of the ect-ethmoid and also projects slightly forwards to form a small roof to the posterior part of the nasal cavity. The anterior end of the ect-ethmoid unites with a dorsal, beak-like process from the vomer. The mesial edge of each ect-ethmoid roofs over the mes-ethmoidal fat cavity.

The ect-ethmoid is bounded by the frontals posteriorly, by the mes-ethmoid dorso-mesially, by the vomer anteriorly and by the parasphenoid postero-ventrally.

Both the mes-ethmoid and the ect-ethmoid are not traversed by any portion of the lateral sensory canal.

Nasal: (*na.*). The nasal is a roughly triangular bone, thin and laminate, and completely roofing over the nasal cavity. It lies in front of and flush with the frontal of its side. From very near its anterior end there is a dorsal shallow depression which widens posteriorly and is continuous with the supra-orbital lateral canal of the frontal. Anteriorly, the nasal lies over the outer ascending process of the premaxilla and the anterior extremity of the maxilla. It is united anteriorly by ligaments to the lachrymal. Its mesial edge lies parallel to the inner ascending process of the premaxilla. At its anterior tip the nasal has a minute foramen-like tunnel. The posterior lateral edge of the nasal forms the inner border of the nasal opening.

Vomer : (*vo.*). The Vomer is a ventro-median unpaired bone without teeth, with a stout, broad, anterior portion which may be called the ' head ', and a thin tapering posterior shaft or ' body '. From each lateral edge of the head arises a process which projects upwards and then mesially and almost meets its fellow of the opposite side in the median line, where a dorsal ridge is formed with its posterior part overlapped by the mesethmoid. The posterior edge of each process is suturally united with the anterior edge of the lateral ethmoid. The antero-dorsal part of the head with its lateral process and the median ridge is curved downwards in the form of a beak. A concave articular surface on each side of the anterior outer end of the head gives an indirect articulation to the corresponding maxillary bone, a thin pad of cartilage separating the two articulating surfaces. Behind this articular surface there is a deep pit on the lateral process on each side into which fits an articular head from the anterior end of the palatine.

The pointed body of the vomer fits completely into a median V-shaped depression on the antero-ventral surface of the parasphenoid which extends forwards, on either side of the body of the vomer to the head.

The dorsal surface of the head of the vomer forms the floor of the mesethmoidal cavity.

Rostral: (fig. 8*a*). This is a single, thick, elongated and narrow, hour-glass-shaped piece of cartilage, with a deep median ventral groove resting on the antero-dorsal ridge of the vomer and the dorsal median ridge of the mesethmoid. On its dorsal

side rest the two inner ascending processes of the pre-maxillaries both of which it serves to bind together. Antero-laterally on each side it is connected by fibrous tissue to the anterior end of the maxillary.

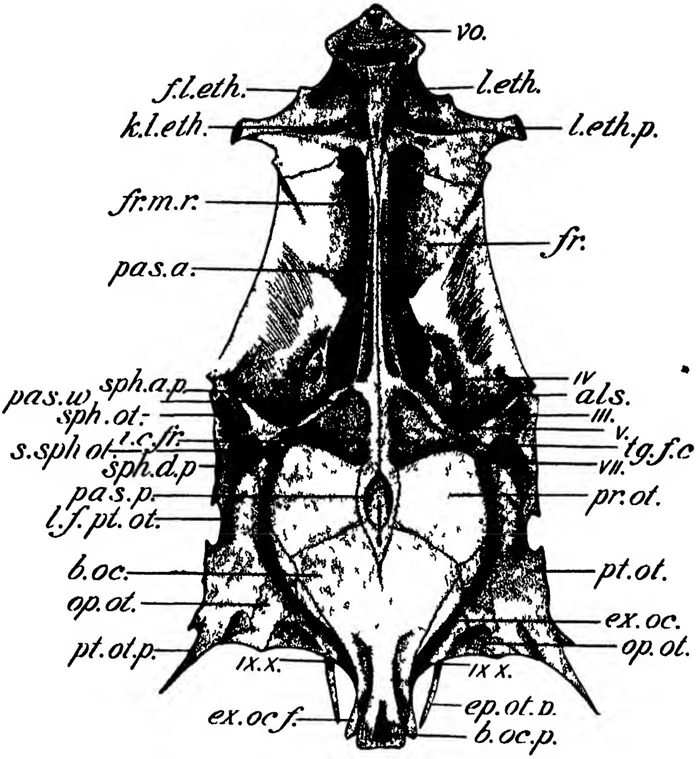

FIG 3. Ventral view of the Skull (×1¼).

als., alisphenoid; *b oc*, basi-occipital; *b oc p.*, posterior articulatory part of basi-occipital, *ep ot p*, epi-otic process, *ex oc*, ex-occipital; *ex oc.f.*, articulatory facet of ex-occipital, *f l.eth*, facet on lateral ethmoid for articulation with palatine; *fr.*, frontal; *fr m r.*, mesial ventral ridge of frontal, *i.c fr.*, internal carotid foramen; *k.l eth.*, knob on lateral ethmoid for palatinal articulation; *l.eth*, lateral ethmoid, *l eth p.*, lateral ethmoidal process, *l f.pt.ot*, longitudinal facet on pterotic for hyomandibular articulation; *op.ot*, opisthotic, *pas a*, anterior part of parasphenoid; *pas.p.*, posterior part of parasphenoid; *pas w.*, wing of parasphenoid; *pr.ot.*, pro-otic; *pt.ot.*, pterotic; *pt ot p*, pterotic process; *sph.a.p.*, pit on sphenotic opening into canal at bottom; *sph.d p*, dorso-lateral pit on sphenotic; *sph ot.*, sphenotic, *s.sph ot*, socket on sphenotic for hyomandibular articulation, *tg.f c*, trigemino-facialis chamber; *vo.*, vomer; *iii.*, foramen for oculomotor nerve; *iv*, foramen for trochlear nerve; *v.*, trigeminal opening of trigemino-facialis chamber; *vii.*, facial opening of trigemino-facialis chamber; *ix, x.*, foramen for glossopharyngeal and vagus nerves.

In the interior of the ethmoid there is a small, oval cavity having the vomer for its floor and the mesethmoid for its roof. In the fresh condition this cavity has been found to be filled with a fatty substance of semi-solid consistency. In all probability it is the 'Mes-ethmoidal fat cavity' (*m.f.c.*) described by Parker (**45**) in *Salmo*.

The nasals and vomer are dermal bones, while the ect-ethmoids and mesethmoid are replacing bones. The rostral remains cartilaginous even in the adult.

2. *Orbito-temporal Region.*

The Orbito-temporal region can be divided into: (i) the Orbital region and (ii) the Temporal or Sphenoidal region. The former includes the two orbits with the bones that go to form the orbital ring, and the latter is sub-divided further into (a) the frontal region; and (b) the parietal region.

The frontal region includes the Frontals and the Orbito-sphenoids.

The Parasphenoid, though properly belonging to the parietal region, has a long anterior part which extends into the frontal region anteriorly and is connected with the vomer.

The Parietal region includes (1) the parietals; (2) the alisphenoids; (3) the basisphenoid and (4) the parasphenoid.

Of the bones of the Temporal region, the frontals, parietals and parasphenoid are dermal in origin, while the alisphenoids and the basisphenoid are cartilaginous in or'; in.

(i) *Orbital Region.*

This region comprises the orbits and the orbital ring bones.

The orbits are large in size and occupy very nearly half the length of the skull. They are separated from each other only by a membranous inter-orbital septum, a bony septum being absent. The skull is therefore said to be Platybasic.[1]

The big orbits cut into the skull to a considerable extent. Each orbit is bounded dorsally by the frontal, anteriorly by

[1] 'As Gaupp has shown, there are two types of skull: the platybasic and the tropibasic. In the former the trabeculae remain wide apart in the orbito-temporal region, an intertrabecular plate unites them in front, and an extensive brain cavity is continued forward to the nasal capsules. This possibly more primitive type is found in the Chondrichthyes and lower Osteichthyes (*Acipenser*, *Amia*, *Polypterus* and some Teleostei such as the Cypriniformes among living forms), Dipnoi and Amphibia. In the tropibasic type the trabeculae tend to fuse immediately in front of the hypophysis to form the base of median interorbital septum continuous with the internasal septum farther forward.

This type occurs in a very pronounced form in the majority of Teleostei and also in the birds and higher reptiles.' (**35**, p. 235).

the lateral process of the lateral ethmoid, posteriorly by the sphenotic and the anterior edge of the alisphenoid and mesially by the membranous septum.

There are five bones, all of them dermal in origin, which contribute to the formation of the orbital ring. All these bones do not form a definite ring because the dorsal supra-orbital is absent. The ring is, however, completed by the part of the frontal in this region. The posterior part of the Lachrymal which is the anteriormost of the five bones, and the remaining four successively one behind the other, the Pre-orbital, the Sub-orbital and the two Post-orbitals, go to form the orbital ring. The second post-orbital secures attachment with the lateral edge of the sphenotic. The pre-, sub-, and post-orbitals are traversed by the infra-orbital lateral line canal.

The Lachrymal (*la.*) is an elongate, roughly rectangular bone situated at the anterior ventral part of the orbit, and directed forwards and upwards. The anterior end of the bone is narrower than the posterior, and the ventral edge longer than the dorsal. In the middle of its dorsal edge there is an inwardly directed process which is connected to the free end of the lateral process of the ect-ethmoid by fibrous tissue and a tiny ligament. The whole lachrymal is situated above the maxillary which it almost entirely hides from view. Its anterior end is connected by fibrous tissue to the anterior end of the maxillary. Its upper edge is thick and the lower edge thin as is the case with all the orbital ring bones. Posteriorly the lachrymal has a V-shaped indentation into which fits the V-shaped anterior end of the post-lachrymal or pre-orbital bone. The lachrymal extends far forwards and its anterior end is united to the antero-lateral edge of the nasal.

The Lachrymal is traversed throughout its length by the infra-orbital lateral canal which is enclosed by processes on the bone.

The Pre-orbital (*pr.ob.*), or the Post-lachrymal of some authors (3), is a flat bone of irregular shape with a V-shaped pointed anterior end which fits into the posterior part of the lachrymal. Its inner edge is much thickened. Posteriorly it is attached to the infra-orbital. It also overlaps the maxilla to a certain extent.

The Infra-orbital or sub-orbital (*sub. ob.*) is a rectangular bone with an irregular outer edge and a concave inner edge. From the middle of its inner edge there is a sharp process, the suborbital shelf, directed inwards into the orbit. The infra-orbital is attached to the pre-orbital in front and the post-orbital behind.

The Post-orbitals (*po. ob.*) are situated next to the infra-orbital. Each is a four-sided bone with a curved, concave inner edge. The first post-orbital is attached to the infra-orbital in front and to the second post-orbital behind; the latter secures

attachment to the lateral edge of the sphenotic and thus completes the orbital ring.

(ii) *Temporal or Sphenoidal Region.*

(a) *Frontal Region.*

The Frontal Region lies between the parietal and the ethmoidal regions. The Orbito-sphenoid being absent in the skull of *Otolithus*, the frontals alone remain to be described.

The Frontals (*fr.*) form the largest part of the dorsal surface of the skull, and occupy about half the full length of that surface. They are suturally united along their entire length in the mid-dorsal line of the head. The anterior end of each frontal rests upon and is united to the posterior edge of the corresponding lateral ethmoid (Pre-frontal), and even extends beyond it slightly, forming a roof to the posterior part of the nasal cavity.

The frontal gradually widens from its anterior end up to the dorsal anterior edge of the sphenotic where its lateral edge recedes inwards and the bone itself is consequently narrow here and presents a postero-lateral recess into which fits the Sphenotic (Post-frontal).

Between the posterior edge of the lateral ethmoid and the anterior edge of the sphenotic the frontal has more than half its breadth arched up laterally and forms the entire roof of the orbit of its side.

The ventral side of each frontal has a well-formed, thick, mesial ridge extending from the lateral ethmoid to the sphenotic. The posterior end of the ridge terminates at the anterior mesial corner of the sphenotic, while its anterior end meets the corresponding arm of the V-shaped parasphenoid, immediately mesial to the olfactory foramen. The frontal ridges run almost parallel to each other upto the anterior edges of the alisphenoids, where they bend outwards to end at the sphenotic bone.

The area between the two orbital convexities is quite flat, while behind it the frontal is curved upwards, so that its posterior third is on a higher level than the anterior two-thirds. The supra-orbital region of the frontal is quite transparent and thin.

The anterior end of the frontal unites mesially with the mesethmoid and laterally the posterior edge of the nasal lies over it.

The hind edge of each frontal has an irregular outline. Mesially it overlaps the anterior edge of the supra-occipital. It also overlaps partly the anterior end of the parietal and is overlapped by it also to a little extent.

The posterior lateral edge of the bone overlaps the mesial edge of the sphenotic.

The frontal is traversed throughout its length by the supra-orbital lateral canal. There are vertical processes (*a.l.l.c.*)

arising from the dorsal surface of the bone each of which arches over a canal-like space (fig. 2).

The frontal is well-ossified in all regions except where it arches over the orbit. The ossification is marked in the region mesial to the ventral ridges and also in front of the sphenotic. In the latter region especially, the bone exhibits a more or less porous nature with fat stored in the minute crevices.

Both the pre- and the post-frontals are absent in this fish.

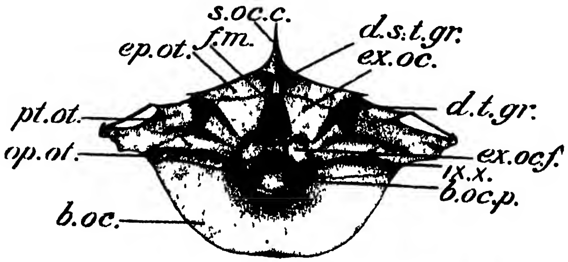

FIG. 4. Posterior view of the Skull ($\times 1\frac{2}{3}$).

b.oc., basi-occipital ; *b.oc.p.*, posterior articulatory part of basi-occipital ; *d.s.t.gr.*, depressed part of supra-temporal groove ; *d.t.gr.*, depressed part of temporal groove ; *ep.ot.*, epi-otic ; *ex.oc.*, ex-occipital ; *ex.oc.f.*, ex-occipital facet ; *f.m.*, foramen magnum ; *op.ot.*, opisthotic ; *pt.ot.*, pterotic ; *s.oc.c.*, supra-occipital crest ; *ix.*, *x.*, foramen for glossopharyngeal and vagus nerves.

(b) *Parietal Region.*

The parietal (*par.*) is a flat, leaf-like, ear-shaped bone with a posterior indentation and a prominent dorsal crest directed upwards and backwards. The two parietals are small in size and do not meet in the middle line, being separated by the median supra-occipital crest which extends to the posterior end of the frontals. The mesial edge of each parietal slightly overlaps the dorsal edge of the supra-occipital ; anteriorly also it overlaps the posterior edge of the frontals. Laterally and postero-laterally it is bounded by the pterotic whose inner edge it lies over, and postero-mesially it suturally articulates with the epiotic. At its antero-lateral corner it unites with the postero-mesial part of the sphenotic.

The parietal does not contribute much towards the formation of the roof of the cranial cavity.

The Alisphenoid (*als.*) is an irregularly triangular piece of bone forming about half of the hind wall of the orbit. It inclines forwards. upwards and slightly inwards. The entire dorsal edge of the bone is rough and is articulated to the posterior part of the mesial ridge on the frontal.

Laterally, the alisphenoid abuts against the sphenotic,

and ventrally, against the pro-otic and the basi-sphenoid. In fact, the anterior half of its ventral edge is borne by the lateral wing of the basi-sphenoid. Its antero-mesial edge forms the complete lateral boundary of the large, median, orbital opening of the brain case. The dorsal boundary of this opening is formed by the mesial ridges on the frontals and also the portion of the frontals between them. The ventral edge is formed by the anterior edge of the basi-sphenoid.

The orbital opening of the cranial cavity is closed by the posterior part of the membranous inter-orbital septum (*i.o.s*) which bends down in this region and terminates a little dorsal to the entrance into the myodome. The second cranial nerve pierces this septum and enters the orbit. This septum does not, however, close the orbital opening of the myodome.

The Basi-sphenoid (*b.sph.*) is a small median Y-shaped bone, characteristic of many Teleosts. The shank of the Y is small and thick, directed downwards and forwards, and lies nearly vertically in the middle plane of the skull. The lower end of the shank is attached to the dorsal side of the para-sphenoid at the beginning of the median dorsal ridge of that bone and opposite to the anterior edges of its wings. The two arms of the Y are quite broad, each directed laterally and a bit upward. The dorsal surface of the two arms put together is concave, and forms the floor of the orbital opening of the cranial cavity. The outer edge of each arm which is directed upward is serrated and upon it rests the alisphenoid of its side, suturally connected with it. Laterally, the arm is connected to the pro-otic bone of its side. Posteriorl,, behind the basi-sphenoidal arms, between them and the anterior end of the united edges of the mesial horizontal processes of the pro-otics (the pro-otic bridge), occurs a small circular opening, the Pituitary Fossa (*pit. op.*) which opens from the cranial cavity into the anterior end of the myodome. Through this fossa the hypo-physis of the brain projects into the myodomal cavity.

The basi-sphenoid, according to Allis (**3**), originally arises from paired centres in the trabeculæ but, in the adult, occurs as a median bone with paired wings.

There is a thick, membraneous Inter-orbital septum (*i.o.s*) which also closes the orbital opening of the cranial cavity. This septum is connected to the middle line of the ventral part of the frontal region and is ventrally attached throughout its length, to the median dorsal ridge on the parasphenoid. At about the middle of its length, very close to its dorsal margin, it is pierced by the olfactory nerve which then enters the orbit and runs close to it, passing on into the nasal cavity through the olfactory foramen. From the anterior end of this septum arise the ***obliquii*** muscles of the eye-ball.

The Parasphenoid (*pas.*) is a long, median, ventral, dagger-shaped bone with two lateral ascending wings or processes arising

from the posterior third of its body, one on each side. It occurs ventral to the primordial cranium and extends from the basi-occipital to the lateral ethmoids. In cross section the bone is V-shaped throughout its length, except at the posterior region where the two arms of the V are almost on a level with each other. A median ridge occurs in the angle of the V right through, but is broken up in the region of the lateral wings and continued posteriorly beyond it. In front of the wings the bone narrows to a small blunt end anteriorly. Behind the wings it expands into a broad, upwardly curved structure which has a small median longitudinal ventral groove and frayed edges and a posterior end tapering to a point.

In the region of the wings, and slightly in front of and also behind them, there is a deep longitudinal channel on the dorsal surface of the bone, which forms the floor of the eye-muscle-canal.

The wings are flat and thin, directed backwards and upwards. The anterior edge of each wing is straight but the posterior is slightly concave. The anterior edge forms the lower half of the hind edge of the orbit and the posterior edge overlaps the ventral half of the anterior edge of the pro-otic bone. The dorsal edge of the wing extends above the level of the horizontal mesial process from the pro-otic and reaches up to the floor of the Trigemino-facial Chamber. Between the pro-otic and the posterior edge of the wing, in the angle formed by that edge with the lateral edge of the parasphenoid, lies the Internal Carotid Foramen, the anterior edge of which is partly overlapped by the hind edge of the wing so that the foramen seems to be enclosed in the parasphenoid.

The posterior end of the vomer overlaps ventrally the anterior end of the parasphenoid to a considerable extent. In fact there is an antero-ventral recess on the parasphenoid for the reception of the body of the vomer.

With regard to the myodome or the eye-muscle-canal it may be stated that 'The Myodome is a space developed in the orbito-temporal and otic regions of the skull of Teleostomes for the accommodation of lengthened recti muscles of the eye. Strictly speaking, this space is the posterior myodome, since a similar anterior myodome is hollowed out for the oblique muscles in the ethmoid region by the enlargement of the orbito-nasal canal.

When fully developed, the myodome in the dry skull is a large space between the floor of the brain-case (pro-otic and basioccipital) and the parasphenoid; it opens behind, and communicates in front with the orbits. The myodome is supposed to have originated by the penetration into the enlarged opening for the pituitary vein of recti muscles originally inserted on the outer surface of the orbital wall.' (**35**, p. 279).

In *Otolithus* the myodome extends from the posterior part

of the orbit to the anterior part of the basi-occipital. It does not extend to the extreme hind end of the skull as in *Salmo* (**45**), but terminates at the anterior end of the basi-occipital where that bone unites with the parasphenoid. It has for its floor the broad posterior part of the parasphenoid which is slightly bent upwards behind. Its roof is formed by the wings of the basi-sphenoid, and by the whole of the mesial, horizontal processes of the pro-otics. Its sides are formed anteriorly by the lateral wings of the parasphenoid and posteriorly by the thin ventro-lateral laminal parts of the pro-otics.

Anteriorly the eye-muscle canal is wide but posteriorly it narrows considerably and almost tapers to a point. Its orbital opening is divided into two by the shank of the basi-sphenoid. Each orbital opening is bounded by the anterior margin of the lateral wing of the parasphenoid, by the basi-

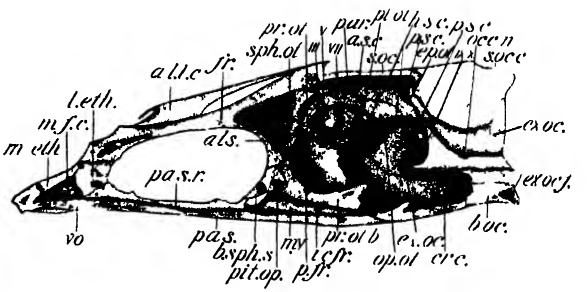

FIG. 5. Median view of the bisected Skull ($\times 2\frac{3}{8}$).

a.l.l.c., arch over lateral line canal; *als.*, ali-sphenoid; *a.s.c.*, anterior semi-circular canal; *b.oc.*, basi-occipital; *b.sph.s.*, basi-sphenoidal shank; *cr.c.*, posterior part of cranial cavity; *ep.ot.*, epi-otic; *ex.oc.*, ex-occipital; *ex.oc.f.*, ex-occipital facet; *fr.*, frontal; *h.s.c.*, horizontal semi-circular canal; *i.c.fr.*, internal carotid foramen; *l.eth.*, lateral ethmoid; *m.eth.*, mesethmoid; *m.f.c.*, mesethmoidal fat cavity; *my.*, myodome; *occ.n.*, foramen for occipito-spinal nerves; *op.ot.*, opisthotic; *par.*, parietal; *pas.*, parasphenoid; *pas.p.*, median vertical process of parasphenoid; *p.fr.*, palatine foramen; *pit.op.*, pituitary foramen; *pr.ot.*, pro-otic; *pr.ot.b.*, pro-otic bridge; *p.s.c.*, posterior semi-circular canal; *pt.ot.*, pterotic; *s.oc.*, supra-occipital; *s.oc.c.*, supra-occipital crest; *sph.ot.*, sphenotic; *vo.*, vomer; *iii.*, oculomotor foramen; *v.*, trigeminal foramen; *vii.*, facial foramen; *ix.*, *x.*, glossopharyngeal and vagus foramina.

sphenoid shank, also by a part of the lateral wing of the basi-sphenoid and by a part of the anterior edge of the pro-otic.

The myodome lodges the recti muscles of the eye, the origin of the rectus inferior being situated at the extreme posterior end of the canal. At about the middle of its length the myodome has the internal carotid foramen opening into it. Through its orbital opening on each side the recti muscles and the internal carotid artery enter the orbit.

The supra-temporal (*s.temp.*) is a thin, triangular, leaf-like, dermal bone occurring dorsally, posterior to the pterotic at the base of the pterotic process and connecting the pterotic with the post-temporal. It is traversed by two canals of the lateral line. There is a posterior arch through which the main infra-orbital lateral canal passes and extends into the pterotic and there is another mesial arch through which the supra-temporal branch of the infra-orbital canal passes.

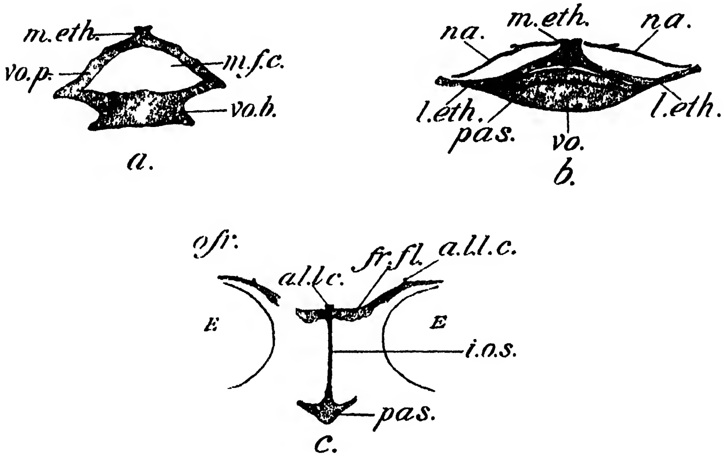

FIG. 6. Transverse sections through three regions in the anterior half of the Skull ($\times 1\frac{1}{2}$).

a, through the mesethmoidal region; *b*, through the nasal region; *c*, through the orbit.

a.l.l.c., arch over lateral line canal; *e.*, eye; *fr.fl.*, flat part of frontal; *i.os.*, membranous inter-orbital septum; *l.eth.*, lateral ethmoid; *m.eth.*, mesethmoid; *m.f.c.*, mesethmoidal fat cavity; *na.*, nasal; *o.fr.*, orbital elevation of frontal; *pas.*, parasphenoid; *vo.*, vomer; *vo.b.*, body of vomer; *vo.p.*, anterior process of vomer.

3. *Otic or Auditory Region.*

In all craniates the auditory capsule of the skull is situated between the facial and the glosso-pharyngeal nerves. In Teleosts it arises as a single piece of cartilage—the Otic Cartilage, which secures connection with the parachordals below. In the otic cartilage five centres of ossification occur which may be recognised as the five bones of the adult fish, namely, the Pro-otic, the Epiotic, the Pterotic, the Sphenotic and the Opisthotic. In *Otolithus* all these five bones unite to form a closed capsule posteriorly on each side of the cranial cavity.

The Pro-otic—(The Petrosal)—(*pr.ot.*), is a large irregular bone forming the antero-mesial and antero-dorsal wall of the auditory capsule. The bone may roughly be said to have a thick body whose posterior portion is depressed in the form of a quadrant of a circle, this part of the bone being thin and transparent, and a mesial horizontal process or wing.

Posteriorly the body of the bone articulates with the basi-occipital and exoccipital; dorso-posteriorly with the opisthotic; dorsally with the pterotic; antero-laterally with the sphenotic and antero-mesially with the alisphenoid. Antero-ventrally the body is overlapped by the lateral wing of the parasphenoid, while ventro-mesially it is united to the body of the parasphenoid.

Of these articulations the one with the basioccipital is more apposition, the two edges lying in juxtaposition with a thin strip of cartilage separating them. In all other cases there are splint-like processes arising from the edges of the pro-otic and also the surrounding bones. The splints of one bone fit into corresponding depressions between the splints of the adjoining bone, a dove-tail sutural articulation being thus effected.

The mesial horizontal process of the pro-otic unites with its fellow of the other side and also anteriorly, with the basis-phenoid and alisphenoid. The united processes together form a platform-like false floor to the cranial cavity in this region. The platform also serves to roof over the myodome and separate it from the cranial case. The mesial horizontal process lies entirely behind the pituitary opening as in *Amia*, and is therefore homologous to that of *Amia* and not to that of *Scomber* (**3**) where a part of the process extends anterior to the pituitary opening. The whole process of *Otolithus* may, however, be said to be homologous to that part of the process of *Scomber* which lies posterior to the pituitary fossa.

The posterior edge of the process reaches up to the anterior edge of the basisphenoid. The process itself slopes downwards posteriorly so that the myodome beneath it also becomes gradually smaller.

The thin and transparent part of the pro-otic is so marked off from the anterior thick part by a deep curved ridge that it may also be considered as a posterior process of the bone. The inner surface of the posterior part of the pro-otic is deeply concave. Antero-dorsally, on the inner surface of the bone there is a circular opening for the passage of the anterior semi-circular canal. Antero-ventrally, the bone has a small incision which lies in the angle formed by the wing of the parasphenoid with the parasphenoid itself. This incision forms the posterior boundary of the internal carotid foramen through which the internal carotid artery passes into the myodome.

Reference may here be made to the Trigemino-facial chamber (*tg.f.c.*) which was first described by Allis (**4, 10**) who gave the

name 'to a space occurring in the side-wall of the skull of Pisces immediately in front of the auditory capsule' (35).

In *Otolithus* it occurs antero-dorsally on the pro-otic bone as a well-defined spacious chamber with two outlets, one directed anteriorly and the other posteriorly. From in front the jugular vein (V. Capitis Lateralis) and from behind the orbital artery pass through it.

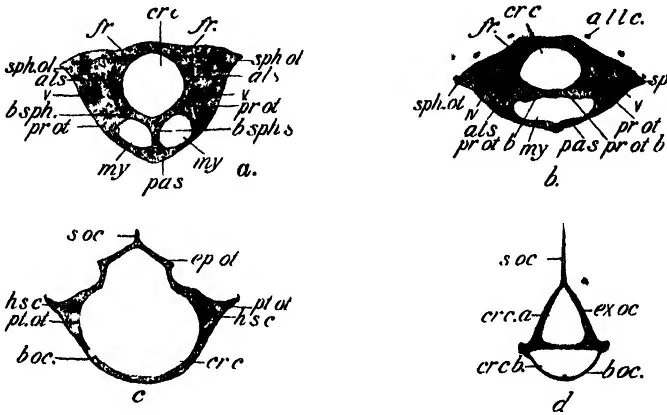

FIG. 7. Transverse sections through four regions in the posterior half of the Skull (Nat. Size.)

a, through the orbital opening of the cranial cavity; *b*, through the anterior part of the pro-otic region; *c*, through the pterotic region; *d*, through the occipital region.

a.l.l.c., arch over lateral line canal; *als.*, alisphenoid; *b.oc.*, basi-occipital; *b.sph.*, basi-sphenoid; *b.sph.s.*, basi-sphenoidal shank; *cr.c.*, cranial cavity; *cr.c.a.*, cranial cavity above ex-occipital platform; *cr.c.b.*, cranial cavity below ex-occipital platform; *ep.ot.*, epi-otic; *ex.oc.*, ex-occipital; *fr.*, frontal; *h.s.c.*, horizontal semi-circular canal; *my.*, myodome; *pas.*, parasphenoid; *pr.ot.*, pro-otic; *pr.ot.b.*, pro-otic bridge; *pt.ot.*, pterotic; *s.oc.*, supra-occipital; *sph.ot.*, sphenotic; *v.*, trigeminal foramen.

Through the anterior opening emerges the Trigeminal nerve with the lateral line branches of the facial and through the posterior comes out the Hyomandibular branch of the Facial nerve All the nerves entering the chamber pierce the wall separating it from the cranial cavity. On the inner side of the wall are situated the trigeminal and facial ganglia in a special recess.

The canal between the two openings of the chamber is called the pars jugularis since the jugular vein passes through it, while the recess for the ganglia is called the pars ganglionaris. The canal and the recess together form the Trigemino-facial chamber.

The Epiotic (*ep.ot.*)—the Exoccipitale of Allis—is roughly cone-shaped, and forms a part of the roof of the auditory capsule. From the posterior end of its flat and small dorsal surface arise the two bony Epiotic processes, the outer, small and directed slightly outwards, and the inner, long, directed backwards and extending up to the posterior end of the skull.

Mesially and antero-mesially, the epiotic adjoins the supra-occipital, ventro-laterally it adjoins the pterotic and posteriorly the exoccipital. The middle of the mesial edges of the two epiotics almost meet but for the slender supraoccipital crest which separates them. Antero-ventrally the epiotic is slightly overlapped by the posterior edge of the parietal. At the origin of the epiotic processes there is a slight depression for the lodging of the distal end of the long process of the post-temporal. This process fits into the depression and is attached to it by muscles and therefore, is capable of some movement.

The lateral and posterior sides of the bone meet posteriorly at an angle of 60°. The former forms the mesial wall of the temporal groove.

Internally, the bone is deeply concave, and its posterior and lateral faces are internally connected by a small bridge of bone enclosing a tunnel through which the posterior semi-circular canal passes. The epiotic is not traversed by the lateral line canal.

The Pterotic (*pt. ot.*)—the Squamosal of Allis—is an irregular bone occuring in the posterior dorso lateral corner of the skull, with its posterior end at a lower level than the anterior. Postero-laterally it has a bifid process, the Pterotic process, whose ventral margin is articulated to the dorsal edge of the opisthotic. Anteriorly the bone adjoins the posterior edge of the sphenotic, and antero-mesially the lateral edge of the parietal. Postero-mesially it adjoins the lateral surface of the epiotic and posteriorly it articulates with the exoccipital and the opisthotic.

The pterotic presents three faces, the dorsal, the lateral and the mesial, the last of these depressed and at a lower level than the other two. The dorsal face lodges the posterior part of the ill-defined dilatator groove. The mesial inferior face forms the lateral wall of the posterior depressed part of the temporal groove.

On the lateral surface of the bone very near the dorsal margin is an elongated shallow groove or facet (*l.f.pt.ot.*) which lodges the posterior part of the articular head of the hyomandibular. The groove begins behind at the base of the pterotic process and inclines slightly ventrally as it proceeds anteriorwards and is continuous anteriorly with the deep socket on the lateral surface of the sphenotic which lodges the ball-shaped anterior part of the articular head of the hyomandibular.

The pterotic is traversed by the horizontal semi-circular canal which perforates internally the lower edge of the bone. Dorsally the pterotic is traversed by the otic section (**3**) or the temporal section (**26**) of the infraorbital lateral line canal.

The Sphenotic (*sph.ot.*) is a bone of irregular shape occurring dorso-laterally at the hind wall of the orbit. It is the anteriormost auditory bone, and has three sides, the dorsal, the anterior and the lateral. The anterior face is inclined forward and upward, and the lateral laterally and downward, each at right angles to the other. The dorsal face is more or less rectangular in outline, while the other two faces are roughly triangular. On the lateral face of the bone very near its ventral apex is a deep, round socket for the accommodation of the anterior ball-like part of the articular head of the hyomandibular. This socket is continuous posteriorly with a lateral groove on the pterotic.

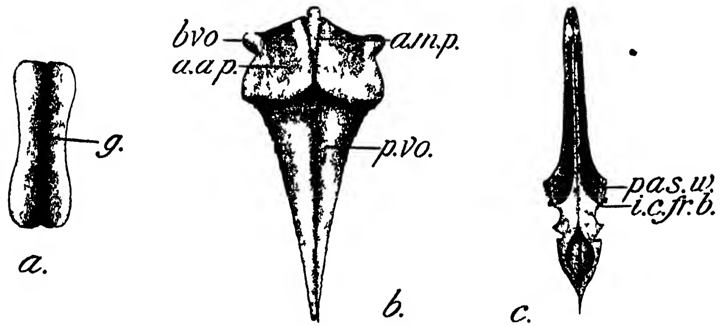

FIG. 8. Skull bones—detached.

a, Rostral (×2); *b*, Vomer (×4), *c*, Parasphenoid (×1¼).

a.a.p., anterior lateral ascending process of vomer; *a.m.p.*, anterior median ascending process of vomer; *b.vo.*, body of vomer; *g.*, median groove on rostral for resting over mes-ethmoid; *i.c.fr.b.*, anterior boundary of internal carotid foramen; *pas.w.*, wing of parasphenoid; *p.vo.*, posterior V-shaped part of vomer.

The sphenotic adjoins the pterotic posteriorly, the parietal at its postero-mesial corner, the dorsal edge of the pro-otic ventrally, and the alisphenoid antero-mesially. There is no cartilage separating it from any of the bones.

On the anterior or orbital face of the sphenotic there is a well-formed deep pit (*sph a.p.*) which I have noted in all specimens that I have examined. From the bottom of this pit there is a canal in the body of the bone, directed upwards and opening behind at the bottom of another large pit (*sph.d.p.*) found posteriorly on the sphenotic, dorsal to the socket for the

hyomandibular articulation. Allis (3) has found a similar condition in the post-orbital ossification (sphenotic) of *Scomber.* He has also noted the passage of the ramus oticus facialis through the canal to the dorsal surface of the skull. He is of the opinion that it represents the spiracular canal of *Amia.*

The internal surface of the sphenotic has a large conical depression which is usually filled with fatty tissue.

The sphenotic is not traversed by the lateral line canal, but dorsally, on its lateral edge, just behind the margin of the orbit, is a small piece of bone with a base and a process arching over it to form a canal. The base merely rests on the lateral edge of the sphenotic and can be easily removed.

The Opisthotic (*op.ot.*)—the Intercalar of Allis—is a small thin, irregular piece of bone bounded anteriorly by the pterotic and posteriorly by the exoccipital. Postero-dorsally it has a small concavity for the reception of the distal end of the smaller process of the post-temporal. In front of the opisthotic there is a small latero-ventral foramen. The opisthotic has no connection with the semicircular canals.

4. *Occipital Region.*

This is the hindmost region of the skull, connected with the otic region in front (one of its bones, however, reaching upto the frontals anteriorly), and posteriorly giving articulation to the first vertebra. It comprises the following bones; the dorsal, median supraoccipital, the ventral, median basioccipital and the lateral exoccipitals. All the bones of this region are ossifications of the chondrocranium.

The Supraoccipital (*s.oc.*) occurs at the extreme hind end of the skull and has two parts, an anterior superior part, flush with the frontals etc., and a longer posterior inferior part inclined downwards and backwards at an angle of 120° to the former. The superior portion is slightly convex dorsally and concave internally, and extends in the form of a platform up to the hindmost point of the skull. Ventrally from about the anterior third of its length starts the inferior portion of the bone. This is slender, elongated and much narrower than the superior. The superior portion adjoins antero-mesially the posterior part of the frontal; antero-laterally it is overlapped slightly by the mesial edge of the parietal; and laterally it adjoins the mesial edge of the epiotic. Beyond the epiotic it runs as the small horizontal platform. The inferior portion adjoins antero-laterally the inferior mesial portion of the epiotic, and postero-laterally the exoccipital. Its posterior end merges imperceptibly into the supraoccipital crest.

The supraoccipital crest (*s.oc.c.*), or spine as it is usually called, arises from the anterior end of the superior part of the bone as a ridge and is directed backwards and upwards. This

ridge separates the supratemporal grooves of the two sides. The crest is thin and transparent and its posterior two-thirds can be clearly differentiated into two portions, an upper small portion and a lower portion with a curved posterior end which goes directly down and meets the two exoccipitals in the mid-dorsal line. These two parts of the crest are separated by the horizontal platform-like posterior prolongation of the antero-superior portion of the body of the supraoccipital. There is no special spine-like ending of the crest as in some Teleosts (*Scomber*).

The supraoccipital bone does not take part in the formation of the boundary of the foramen magnum nor is it traversed by the lateral line canal and its branches.

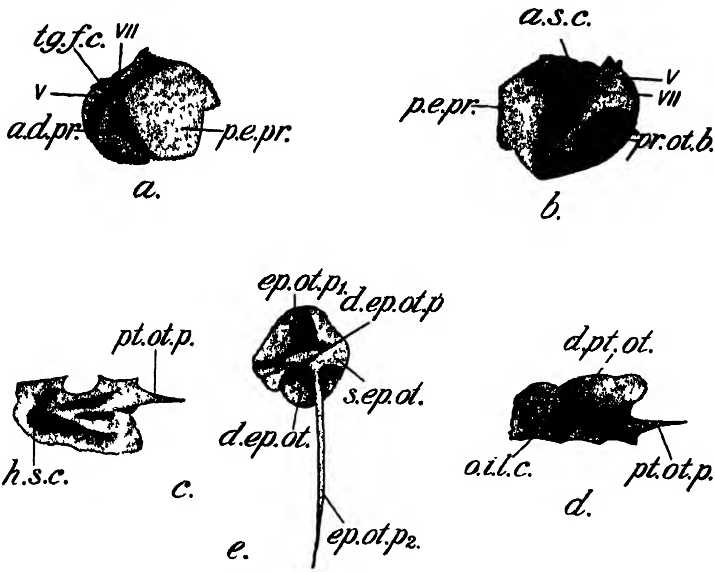

FIG. 9. Bones of the Otic region of the Skull—disarticulated ($\times 1\frac{1}{2}$).

a, External view of left pro-otic; *b*. Internal view of left pro-otic; *c*, Internal view of left pterotic; *d*, External view of left pterotic; *e*, Dorsal view of epi-otic.

a.d.pr., anterior depressed part of pro-otic; *a.s.c.*, anterior semi-circular canal; *d.ep.ot.*, depressed part of epi-otic; *d.ep.ot.p.*, depression on epi-otic process for lodgement of post-temporal limb; *d.pt.ot.*, depressed part of pterotic; *ep.ot p*$_1$., epi-otic process (short); *ep.ot.p*$_2$., epi-otic process (long); *h.s.c.*, horizontal semi-circular canal; *o.i.l.c.*, otic section of infra-orbital lateral line canal; *p e.pr.*, posterior elevated part of pro-otic; *pr.ot.b.*, pro-otic bridge; *pt.ot.p.*, pterotic process; *s.ep.ot.*, superior part of epi-otic; *tg.f.c.*, trigemino-facialis chamber; *v.*, trigeminal foramen; *vii.*, facial foramen.

The Basioccipital (*b.oc.*) is a large mid-ventral bone at the posterior end of the skull, broad anteriorly and gradually narrowing posteriorly. The thick posterior end of the bone has a deep concavity resembling that of the centrum of a vertebra, with its ventral surface slightly longer than the dorsal and the depth of the concavity almost equal to its diameter. The posterior end of the bone is connected to the anterior end of the first vertebra by ligaments. The anterior end of the first vertebra also has a deep conical depression which together with that on the posterior end of the basioccipital, forms between the two bones a compact space filled with notochordal tissue.

The myodome is not continued into the basioccipital but stops with the posterior end of the parasphenoid. Mid-dorsally on the basioccipital is a longitudinal ridge running its entire length and abutting anteriorly against the posterior end of the eye-muscle-canal.

Anteriorly the basioccipital has a ventral V-shaped depression in which the posterior part of the parasphenoid fits. Postero-ventrally also, on the vertebra-like part there is a small depression.

The basioccipital gives articulation to the parasphenoid mid-anteriorly, to the pro-otic latero-anteriorly, and latero-dorsally on each side it supports the corresponding exoccipital.

The two horizontal mesial processes from the exoccipitals form the floor of the foramen magnum and separate it from the basioccipital, which consequently does not take part in the formation of the foramen.

The Exoccipital (*ex.oc.*)—the ' Occipitale Laterale ' of Allis —is a paired bone occurring one on each side and together forming in their posterior parts, a complete boundary for the foramen magnum. Three parts can be recognised in each exoccipital. There is a dorsal wing-like part, a middle inner mesially directed horizontal process, and a ventral wing. The dorsal process is at an angle of 60° to the horizontal process and the ventral process almost at right angles to it. The horizontal process meets its fellow in the middle line forming a platform—the floor of the foramen magnum.

The lateral expansions of the bone—the so-called Paroccipital processes—described in many fishes (*e.g.*, *Labeo rohita* by Sarbahi, **52**) do not occur here.

Antero-laterally, the exoccipital adjoins the pro-otic, antero-dorso-laterally the pterotic, and antero-dorsally the epiotic. Dorso-medianly it unites with its fellow of the opposite side, and the adjoining edges of the two bones are more or less covered externally by the lower edge of the posterior part of the supraoccipital crest. Ventrally, each exoccipital rests on the corresponding lateral uplifted edge of the basioccipital. The posterior part of the dorsal wing of each exoccipital is thickened considerably and this, with the corresponding thickening

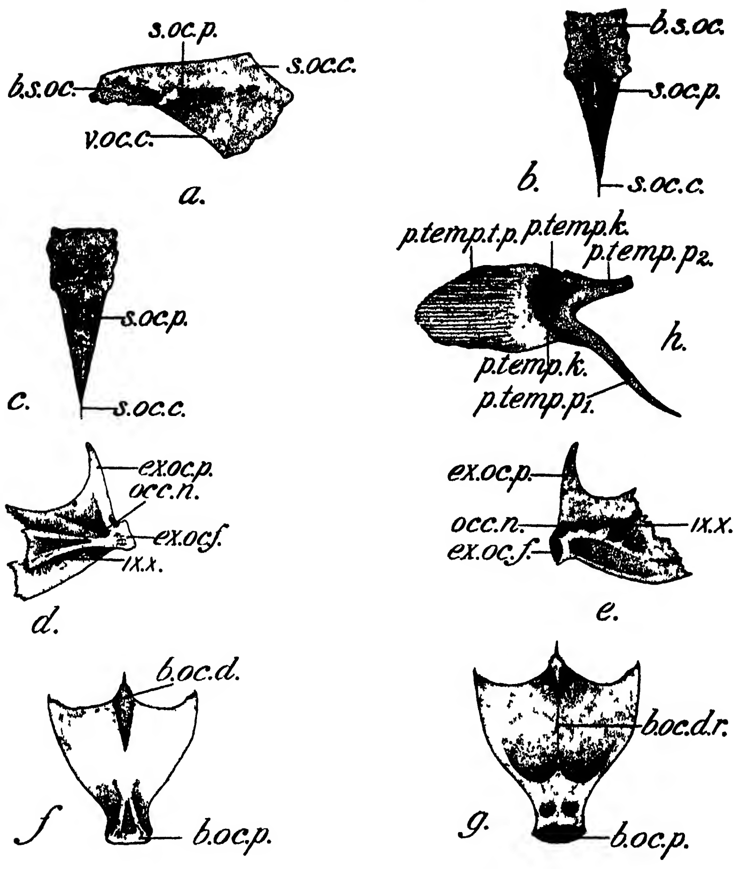

FIG. 10. Skull bones—detached ($\times 1\frac{1}{2}$).

a, Side view of supra-occipital; *b*, Dorsal view of supra-occipital; *c*, Ventral view of supra-occipital; *d*, External view of left ex-occipital; *e*, Internal view of left ex-occipital; *f*, Ventral view of basi-occipital; *g*, Dorsal view of basi-occipital; *h*, Dorsal view of left post-temporal.

b.oc.d., depression on basi-occipital for lodging parasphenoid; *b.oc.d.r.*, dorsal ridge on basi-occipital; *b.oc.p.*, posterior articulatory part of basil occipital; *b.s.oc.*, body of supra-occipital; *ex.oc.f.*, ex-occipital facet; *ex.oc.p.*, posterior ex-occipital process; *occ.n.*, foramen for occipito-spinal nerve; *p.temp.k.*, knobs on post-temporal for supra-cleithral articulation; *p.temp.p*$_1$., post-temporal process (long); *p.temp. p*$_2$., post-temporal process (short); *p.temp.t. p.*, thin laminar part of post-temporal; *s.oc.c.*, supra-occipital crest; *s.oc.p.*, internal platform of supra-occipital; *v.oc.c.*, ventral margin of occipital crest uniting with ex-occipitals; *ix.*, *x.*, foramina for glossopharyngeal and vagus nerves.

of the other side, forms the strong lateral and dorsal boundary of the foramen magnum. Between the dorsal and the ventral wings, at the level of the horizontal process, is an external, stout ridge which runs laterally throughout the length of the bone and widens out posteriorly into the large flat oval exoccipital facet for articulation with a similar facet on the first vertebra. The facets occur below the floor of the foramen magnum and above the circular concavity of the basioccipital.

About the middle of the length of the exoccipital and ventral to the lateral ridge on it, is a large oval foramen for the passage of the glosso-pharyngeal and vagus nerves. Posterior to this and dorsal to the ridge is another large foramen, which with one or two more minute foramina occurring in this region forms the exit of the spino-occipital nerves.

(*b*) VISCERAL SKELETON.

In all Gnathostomes, the Visceral Skeleton is made of seven visceral arches, which arise from the splanchnic mesoblast, and are originally quite independent of the chondrocranium proper (neurocranium) and lie in the pharyngeal wall internal to the coelom. Each arch at first arises as a half loop, the two halves later uniting in the mid-ventral line to form a single arch. The union of all the arches in the mid-ventral line gives rise to the visceral skeleton or basket.

The behaviour of the first two of these seven arches is interesting. Their connection with the chondrocranium is established early. The first or the Mandibular arch gives rise to two cartilaginous pieces—the Palato-quadrate and the Mandibular or Meckel's Cartilage. In Teleosts the palato-quadrate or the palato-pterygo-quadrate bars of the two sides do not meet in front in the middle line but become connected to the lateral ethmoidal processes. The posterior quadrate part serves to support the Meckel's Cartilage and the anterior pterygo-palatine part forms the roof of the palate. The Premaxilla, the Maxilla and the Dentary arise dermally and bear the biting teeth. The Meckel's Cartilage is usually replaced by the dermal Dentary, Articular and Angular.

The second or the Hyoid arch gives rise to the Hyomandibular which connects the two jaws to the auditory capsule, and the Hyoid arch or Cornu.

The remaining five arches are the Branchial arches which are loosely attached in front to the hyoid arch. Only the first four support the gills, while the last is transformed into the so-called Inferior Pharyngeal bones which bear teeth used in mastication. Each branchial arch is sub-divided into paired dorsal Pharyngo-branchials, Epi-branchials, lateral Cerato-branchials, and ventral Hypobranchials, united together in the mid-ventral line by a median unpaired Basibranchial.

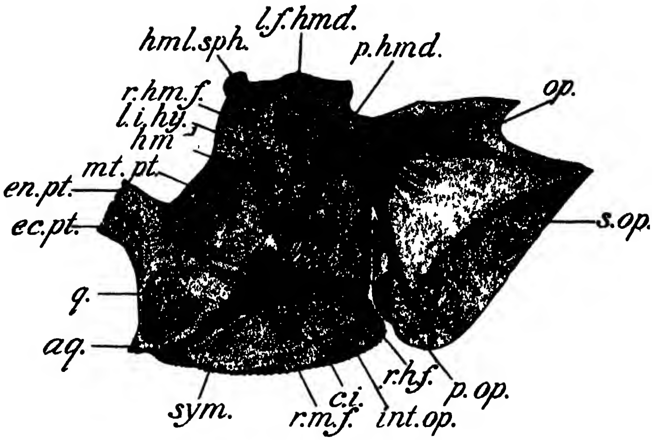

FIG. 11. Intornal view of right opercular skeleton ($\times 1\frac{1}{4}$).

a.q., articulatory head of quadrate; *c.i.*, cartilaginous interspace; *ec.pt.*, ecto-pterygoid; en.pt., ento-ptorygoid; *hmd.*, hyomandibular; *hmd.sph.*, process of hyomandibular articulating with sphenotic depression; *int. op.*, inter-operculum; *l.f.hmd* longitudinal facet of hyomandibular for articulation with pterotic; *l.i.hy.*, foramen for ligament from interhyal to sphenotic; *mt.pt.*, meta-pterygoid; *op.*, operculum; *p.hmd.*, posterior articular process of hyomandibular for the opercular; *p.op.*, pre-operculum; *q.*, quadrate; *r.h.f.*, foramen for ramus hyoideus facialis; *r.hm.f.*, foramen for ramus hyomandibularis facialis; *r.m.f.*, foramen for ramus mandibularis facialis; *s.op.*, sub-operculum: *sym.*, symplectic.

1. *First or Mandibular Arch.*

The first or the Mandibular arch, as stated before, divides into two parts—the Palato-pterygo-quardate bar and the Meckel's Cartilage. The former is ossified into three bones, the Quadrate, the Palatine and the Metapterygoid, and it gets attached to the cranium to form the primary upper jaw. Two dermal bones, the Ecto-pterygoid and the Endo-pterygoid, get later on added to the bar. None of these bones forms the gape of the mouth. The adult upper jaw is formed of two dermal bones, the Premaxilla (Premaxillary) and the Maxilla (Maxillary), the former alone forming the margin and bearing teeth.

The Meckel's Cartilage is ossified only in the articular region and persists as a small rod of cartilage in the adult lower jaw. Two bones, the Dentary and the Angular, are later on added to it. These two and the articular together form the adult lower jaw.

The Upper jaw is attached to the auditory region of the cranium by the intervention of the Hyomandibular and the Symplectic. In front it is attached by the Palatine to the

ethmoidal region. It comprises the Palatine, the Ento-pterygoid (Endo-pterygoid, Meso-pterygoid), the Ecto-pterygoid (Trans-palatine), the Quadrate, the Metapterygoid, the Premaxilla and the Maxilla.

The Palatine (*pal.*) is a large, thin, transparent, edentulous bone with a pointed posterior end which abuts against the anterior surface of the downwardly bent arm of the ecto-pterygoid. Its ventral edge is smooth and concave, while its dorsal edge is quite straight but for a few bony splints at its anterior end. Directed outwards from the dorsal edge is a thin tall ridge of bone exactly at right angles to the leaf-like body of the bone. This ridge runs anteriorly and merges into a thick and massive articulatory process arising from the anterior end of the palatine. The process is directed downwards and outwards, and dorsally at its base is a deep V-shaped concavity into which the ventral ball-like knob of the lateral ethmoid fits. Anterior to this depression is a dorsal ill-defined facet which glides under a similar one found dorsally on the lateral ethmoid at the base of the lateral ethmoidal process.

Ventrally also there is a small facet on the palatine at the base of its articulatory process. This facet glides over a flat surface at the lateral corner of the diamond-shaped head of the vomer.

The articulatory process of the palatine is directed anteriorly, its tip being lodged in a depression on the anterior dorsal edge of the maxilla and bound to it by connective tissue. Antero-dorsally, the palatine has splint-like processes (behind the articulatory process) which articulate with similar processes at the anterior end of the ecto-pterygoid. For the rest of the length of its dorsal edge it adjoins the ventral edge of the ento-pterygoid.

The Endo-pterygoid (*en.pt.*)—Pterygoid—is a leaf-like triangular bone occurring dorsal to the palatine and the ecto-pterygoid. Anteriorly it unites with the palatine; its whole lateral edge adjoins the ecto-pterygoid, and posteriorly it passes inwards of the meta-pterygoid uniting with the inner face of that bone. From its lower posterior angle there is a splint-like process which unites with the inner face of the quadrate. The mesial edge of the endo-pterygoid is free. The whole bone is quite transparent except at the posterior lower angle where ossification is pronounced.

The Ecto-pterygoid (*ec.pt.*) is a well-ossified, laterally compressed, L-shaped bone with its long arm wedged in between the endo-pterygoid and the palatine and the short, pointed arm, about half the length of the former, bent downwards and backwards. The dorsal edge of the long arm adjoins the lower edge of the endo-pterygoid throughout while its ventral edge adjoins the palatine only for the anterior three-quarters of its length. Ventrally, the bone has a V-shaped depression

slightly anterior to the bend and in this is received the pointed posterior end of the palatine. The entire posterior edge of the short arm adjoins the quadrate while its anterior edge is free.

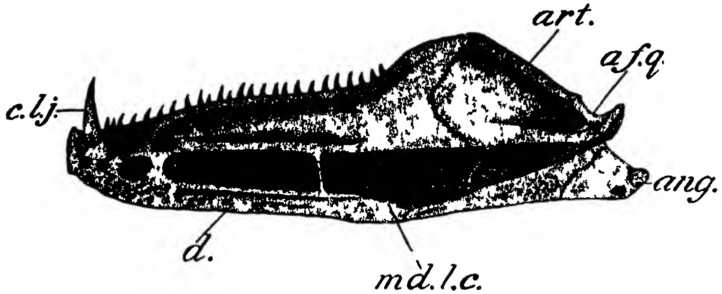

FIG 12. External view of left half of lower jaw ($\times 2$).

a f q, facet on the articular for quadrate; *ang*, angular; *art.*, articular; *c l j*, canine of lower jaw; *d.*, dentary, *md l c*, mandibular lateral line canal.

The Quadrate (*q*) is a triangular bone with straight dorsal and ventral edges and a convex posterior edge, and resembling a quadrant of a circle. It fits into the lower part of the concave anterior end of the pre-opercular bone, and is thickened along the posterior edge, with a shallow groove extending upto very near its posterior angle. Into this groove fits the anterior end of the pre-opercular. The posterior thickening is also continued dorsally to a short distance beyond the body of the bone as a small process behind the symplectic.

At the posterior lower angle of the quadrate there is an articular surface (*a.q.*) which is concave in a transverse direction and convex in the longitudinal. This surface usually possesses a cartilaginous lining and gives articulation to a corresponding surface at the posterior dorsal surface of the articular of the lower jaw.

On the inner surface of the quadrate, parallel to its posterior convex edge, is a long V-shaped groove the apex of the V almost reaching up to the articular surface of the bone. This groove lodges the symplectic bone. The symplectic, however, does not entirely fill the groove, and the small amount of space between it and the posterior dorsal process of the quadrate is occupied by the *ramus mandibularis facialis* which passes through this region.

Dorsally, separating the quadrate and the lower edge of the meta-pterygoid, is a thin line of cartilage. Antero-dorsally it unites with the posterior splint from the endo-pterygoid. Antero-ventrally it unites with the posterior end of the downwardly directed short arm of the ecto-pterygoid.

The Meta-pterygoid (*mt.pt.*) is a large roughly four-sided bone lying dorsal to the quadrate and ventral to the hyomandibular. Its anterior edge is free except at its lower third where it overlaps the posterior end of the endo-pterygoid. Dorsally it articulates with the ventral edge of the main body of the hyomandibular. Posteriorly the upper half of its edge adjoins the rod-like process of the hyomandibular and slightly overlaps it. The lower half of its posterior edge adjoins the symplectic which is also overlapped by it.

Ventrally the meta-pterygoid possesses tiny bony splints which pass inner to the cartilaginous lining separating it and the quadrate.

About the middle of the dorsal edge of the bone there is a slight indentation which partially bounds a circular opening (*l.i.hy.*) directed upwards. A similar indentation on the ventral edge of the hyomandibular completes the boundary of the opening through which a large tendon-like ligament passes dorsalwards (from internal to the hyomandibular arch) and is inserted on the antero-lateral corner of the sphenotic. The other end of the ligament is connected to the interhyal bone.

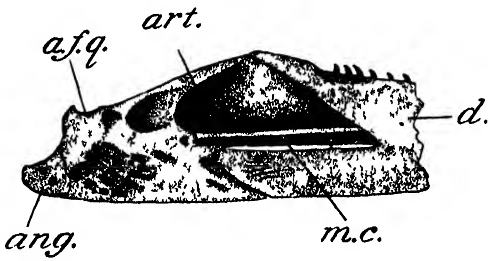

FIG. 13. Internal view of posterior part of left half of lower jaw ($\times 1\frac{1}{3}$).

a.f.q., facet on the articular for quadrate; *ang.*, angular; *art.*, articular; *d.*, dentary; *m.c.*, meckel's cartilage.

The Premaxilla (*pmx.*) is a long curved bone slightly shorter than the maxilla and with a sharp posterior end. Its triangular anterior end which is upwardly and backwardly directed (with the apex of the triangle directed upwards) forms the anterior ascending process (*a.a.pmx.*) of the bone. There is a posterior ascending process (*p.a.pmx.*) broader but shorter than the anterior, situated slightly in front of the extreme posterior end of the bone. Between the two processes the bone is slender and rod-like.

In front of the anterior ascending process of the premaxilla there is a laterally compressed process (*f.a.pmx.*) ascending at right angles to the body of the bone, pointed at its free end and directed upwards and slightly forwards. Its free end is

almost united to the end of its fellow of the opposite side and bound to it by connective tissue, and the two processes lie over the rostral, completely hiding it from view. The processes are so long that they abut against the median line of the frontal region. They meet dorsally, enclosing a triangular depression between them at the anterior end of the skull and in the basal part of this depression lie the tips of the canines of the lower jaw when the mouth is closed. The nasal bone lies on the side of each process.

The straight ventral edge of the premaxilla bears a strong lateral ridge throughout its length. Posterior to the second anterior ascending process, the whole premaxilla is overlapped by the maxilla, and only the anterior ascending process, the ventrolateral ridge and the part of the bone below it are visible externally. There is no definite articulation between the premaxilla and the maxilla, but the second anterior ascending process of the former has at its inner posterior surface a knob which fits into a socket at the anterior end of the latter.

The whole ventral edge of the premaxilla bears two rows of teeth, an outer, consisting of a few large downwardly and backwardly directed stout teeth, and an inner zig-zag row of

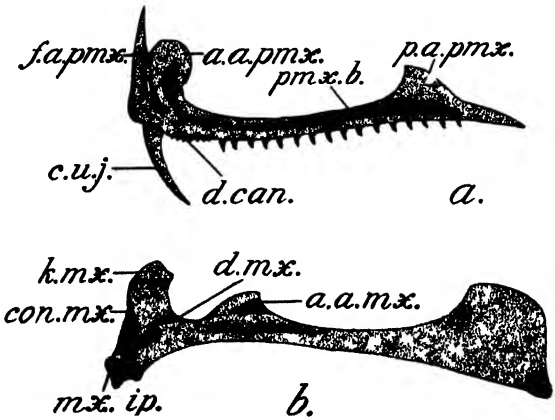

FIG. 14. The maxillary bones (× 1⅗).

a, The pre-maxilla ; *b*, The maxilla.

a.a.mx., anterior ascending process of maxilla ; *a,a.pmx.*, anterior ascending process of pre-maxilla ; *con.mx.*, concavity for lodging the second anterior ascending process of pre-maxilla ; *c.u.j.*, canine of the upper jaw ; *d.can,*. position of fallen canine ; *d.mx.*, U-shaped depression on maxilla lodging the palatinal process ; *f.a.pmx.*, pointed, flat, anterior ascending process of pre-maxilla ; *k.mx.*, knob of maxilla gliding over lateral ethmoid ; *mx.i.p.*, inwardly directed process of maxilla ; *p.a.pmx.*, posterior ascending process of pre-maxilla ; *pmx.b.*, compressed body of pre-maxilla.

more numerous, small, villiform teeth. Very often no definite row may be recognised, the whole edge of the bone inner to the outer row being studded with teeth. One or two teeth of the outer row, on either side of the middle line, may be specialised into large canine teeth characteristic of *Otolithus*. Two canines usually occur on each half of the upper jaw, but occasionally three on one side and two on the other, and more rarely three on each side. On the anterior end of each dentary, are slight depressions with small canals at their bottom and into these canals are lodged the tips of the premaxillary canines when the mouth is closed.

The gape of the mouth is formed entirely by the premaxilla.

The Maxilla (*mx.*) is a long, thick, curved bone, very broad behind and abruptly becoming narrow in front and lying dorsal to the premaxilla. Anteriorly it has a small ascending process (*a.a.mx.*). In front of this the bone has another process, thick, stout and directed inwards, downwards and slightly forwards (*mx.i.p.*). On the anterior face of the bone, at the origin of this process, is a deep cancavity (*con.mx.*) into which the second ascending process of the premaxilla fits. The dorsal wall of the concavity is raised up and terminates in a well-defined knob (*k.mx.*) which articulates with the ect-ethmoid of its side in front of the lateral ethmoidal process. The inwardly directed stout process is connected to the antero-lateral side of the vomer by fibrous tissue. Posterior to the depression mentioned above and in front of the small process of the maxilla, is another U-shaped depression (*d.mx.*) which lodges the tip of the anterior process of the palatine.

The maxilla is convex on its outer surface. It overlaps the premaxilla throughout, the latter bone reaching to about three-fourths of the length of the former, and its posterior end lies over the anterior part of the articular.

The maxilla bears no teeth and takes no part in the formation of the margin of the upper jaw. External to it lies the lachrymal with its anterior edge adjoining the nasal and hiding completely from view nearly five-sixths of the maxilla. The pre-orbital covers the postero-dorsal part of the maxilla.

The Lower jaw, as already stated, is in the form of a single cartilaginous piece—the Meckel's Cartilage—which secondarily gets partly replaced by bone and also has dermal bones attached to it. Thus in the adult fish three bones are recognized, the Dentary, the Articular and the Angular. The Meckel's Cartilage may also persist in the adult, as in *Otolithus*, as a slender cartilaginous rod.

The double origin of each of the three bones of the lower jaw is interesting. The articular and the angular are formed by the fusion of endochondral and dermal elements. Similarly the dentary originates as the result of a fusion between

a true dermal dentary and a small anterior endochondral element which probably represents the Mento-Meckelian (**35**, **49**, **50** and **45**).

In the lower jaw of *Otolithus* all the three bones and the Meckel's Cartilage are present.

The Dentary (*d.*) is a large, broad, elongated bone, narrow in front and of uniform breadth posteriorly, having, in this region, a V-shaped indentation on its inner aspect. Laterally, on the outer face of the bone at about the middle of its breadth and running its whole length is a strong ridge below which is a broad shallow groove with the anterior end of the mandibular lateral canal situated in it.

The whole dorsal edge of the dentary except the hind extremity bears a single row of small well-developed teeth. On either side of the mid-anterior line there is a large canine on each dentary. The two canines lodge in the depression between the two anterior ascending processes of the premaxillæ, in the closed condition of the mouth.

The anterior end of the dentary bends slightly mesially and unites with its fellow of the opposite side along a straight line but the surface of the uniting end is rugged.

The V-shaped indentation is continued in the interior of the bone to its front end, as a tiny groove maintaining a dorsal position. Into this groove extends the anterior end of the Meckel's Cartilage.

Mesially at its anterior end there is a longitudinal depression on the dentary for the insertion of the intermandibularis muscle.

The Articular (*art.*) is a large, irregular, thick bone with two anterior triangular processes, a long dorsal and a short ventral, the former nearly twice as long as the latter, and the two meeting at an angle of about 30°. From this angle starts the meckel's cartilage. The dorsal process runs into the internal groove in the dentary. The ventral process merely abuts against the posterior end of the ventral half of the dentary.

Dorsally, at the extreme hind end of the articular there is a depressed articular surface for articulation with the quadrate, concave in the longitudinal direction of the bone and slightly convex in the transverse. The posterior end of this surface rises upward as a process which is slightly bent and rests in a corresponding recess at the hind end of the quadrate. A thin lining of cartilage was noticed on the articular surface.

The external face of the ventral half of the articular presents a shallow groove in which the posterior part of the mandibular lateral canal (*md.l.c.*) is lodged.

Postero-ventrally the articular unites with the anterior end of the angular. The articular bears no teeth.

The Angular (*ang.*) is a small triangular bone found attached to the ventral half of the posterior edge of the articular, beneath the articular surface on that bone. The narrow and blunt

posterior edge of the angular has a small lateral process and is directed slightly downwards. Anterior to this process is a depression to which is attached a strong tough ligament whose broad posterior end is inserted on the inner surface of the interoperculum. The angular is not traversed by any part of the lateral line canal.

The Meckel's Cartilage (*m.c.*) is a long, thin, cylindrical rod of cartilage arising from the angle formed by the dorsal and ventral anterior processes of the articular, and extending forwards into the internal groove in the body of the dentary and terminating very near to the anterior end of that bone.

The Working of the Jaws: The maxillary, premaxillary and the rostral are strongly bound together by fibrous or ligamentous tissues, and the premaxillary is similarly bound to its fellow of the opposite side. The five bones (two maxillaries, the two premaxillaries and the rostral) thus form a compact single piece with little movement between the components. The whole piece forms the upper jaw of the fish and is capable of a certain amount of movement upon the anterior end of the cranium to which it is attached not only by fibrous tissue but also, on each side of the head by the ethmoido-maxillary ligament. This arises on each side of the mesethmoid bone and passes beneath the lachrymal and is attached to the outer face of the anterior end of the maxilla of its side. From the apex of the mesial face of the pointed first anterior ascending process of the premaxillary there arises a stout ligament which passes over to the opposite side lying over the similar process of the premaxilla of the other side, and is inserted on the anterior ascending process of the palatine of the opposite side. This condition recalls that found in the skull of the Haddock (**23**).

In the closed condition of the mouth, the shanks of the premaxilla and maxilla pass upwards, internal to the lachrymal, and are hidden from view by that bone, its lower edge forming the margin of the upper lip. A slight fold of dermal tissue of the lip extends upwards between the maxillary and the premaxillary. A second fold extending from the hind part of the mandible to very near the anterior end of the snout, lies between the maxillary and the lachrymal. The hind ends of the premaxilla and the maxilla are slightly enlarged and strongly bound together by dermal tissue. When the mouth is closed these hind ends lie in a depression on the outer surface of the lower jaw at its posterior dorsal end. They are also connected to the mandible by strong dermal tissue which pulls them downwards and forwards when the mouth is opened. They are pulled back to position by the same tissues when the mouth is closed, but in addition there is the action of a long tendon of the adductor mandibulæ arising from the lower end of the muscle and inserted on the external face of the maxillary at its ventral edge very near its anterior end.

2. *Second or Hyoid Arch.*

The second or Hyoid arch, like all the other visceral arches, consists of two half-loops united together by a median basihyal. Each half-loop divides into two portions, (1) a dorsal Hyomandibula which ossifies into two bones, a Hyomandibular bone above, articulating with the auditory capsule, and a Symplectic below connected with the quadrate, and (2) a ventral Hyoid Cornu which ossifies into three bones. These are, from above downwards, an Epihyal, a Ceratohyal and a Hypohyal, the last of these being double. The hypohyals of the two sides are united by the median Basihyal or Copula. A small rod-shaped bone, the Stylo-hyal or Inter-hyal lies between the dorsal edge of the epihyal of the Hyoid Cornu and the symplectic of the hyomandibula

The four dermal opercular bones are connected to the Hyoid arch. There are seven Branchiostegal rays all of them con-

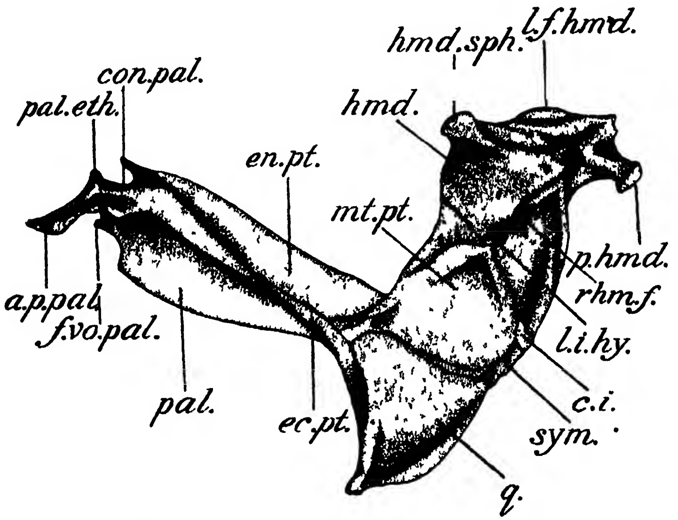

FIG. 15. External view of left hyomandibulo-symplectic and palato-quadrate apparatus (× 1⅓).

a.p.pal., anterior articulatory process of palatine; *c.i.*, cartilaginous interspace; *con.pal.*, concavity on palatine for ventral ball-like ect-ethmoidal knob; *ec.pt.*, ecto-pterygoid; *en.pt.*, ento-pterygoid; *f.vo.pal.* facet of palatine fitting into lateral corner of vomer; *hmd.*, hyomandibular; *hmd.sph.*, hyomandibular process for articulating with sphenotic depression; *l.f.hmd.*, longitudinal facet of hyomandibular for articulation with pterotic; *l.i.hy.*, foramen for ligament from interhyal to sphenotic; *mt.pt.*, meta-pterygoid; *pal.*, palatine; *pal.eth.*, palatinal facet for gliding beneath ect-ethmoidal facet; *p.hmd.*, posterior articular process of hyomandibular for operculum; *l.*, quadrate; *r.hm.f.*, foramen for ramus hyomandibularis facialis; *sym.*, symplectic.

nected to the epihyal and ceratohyal. The median Urohyal or Basi-branchiostegal bone is present and occurs posterior to the basihyal.

The Hyomandibula forms the suspensorium for the two jaws and this condition where the jaws are attached to the skull through the intervention of the hyomandibula is called Hyostylic,[1] a mode of suspension characteristic of all Teleosteans and the majority of the Selachii.

The Hyomandibula results in two ossifications, the Hyomandibular and the Symplectic.

The Hyomandibular (*hmd.*) has an irregular flat body with a posterior ventrally directed, rod-like process. Anteriorly, dorsally, and posteriorly the body of the bone has three articular surfaces. The anterior and posterior ones are ball-like, rounded and situated at the end of small processes from the bone. The anterior process is directed forwards and upwards and the posterior, backwards and downwards. The dorsal articular surface is elongated. All these articular surfaces are capped with cartilage in the fresh condition. The anterior ball-like surface (*hmd.sph.*) fits into the lateral depression on the sphenotic, the dorsal elongated surface (*l.f.hmd.*) into the lateral ventral groove on the pterotic, and the posterior knob (*p.hmd.*) gives articulation to the opercular bone.

The inner face of the bone is smooth while on the outer, there are two well-marked erect ridges. One of these is situated on the posterior ventral process running parallel to it and lying on its posterior edge; the other starts from the middle of the hyomandibular and is directed forwards and downwards making an angle of 45° with the former. The second ridge separates the body of the bone anterior to the postero-ventral process, into two parts. Behind it, on the postero-ventral process there is a deep groove the outer wall of which is formed by the ridge itself. Into this groove fits the dorsal part of the anterior end of the pre-opercular.

About the middle of the anterior edge of the hyomandibular, immediately behind it and also partly covered by it is

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[1] According to Huxley three types of jaw-suspension can be distinguished: In Dipnoi and possibly in the Holocephali, we get the *Autostylic* type where the hyomandibular takes no part in the suspensorium and the quadrate region articulates directly with the auditory region of the skull.

The second type, the *Hyostylic*, is found in the majority of Selachii and in all the Teleostomes. Here the quadrate region is articulated to the skull through the intervention of the hyomandibular.

The third and last type is the *Amphistylic* type, which occurs only among the more primitive Chondrichthyes (Notidani and early Heterodonti among Selachii, Pleuracanthodii, Acanthodii, Cladoselachii). In this case there exists an otic process which serves to connect the quadrate region directly to the skull, and in addition to this the hyomandibular also takes part in the suspension. (Goodrich, **35**: Studies on the Structure and Development of Vertebrates, p. 409 *et. seq.*).

a circular opening (*r.hm.f.*) facing downwards and leading into a small canal in the bone, whose other opening is found on the internal face of the bone itself. This canal and opening is for the passage of the ramus hyomandibularis facialis. Slightly anterior to this is another opening (*l.i.hy.*) which faces upwards and leads downwards into a canal which also opens internally. Through this the ligament from the inter-hyal passes and ends on the antero-lateral corner of the sphenotic.

In front of the proximal end of the postero-ventral process of the hyomandibular and near the ventral end of the anterior ridge of the bone, the posterior edge of the metapterygoid sends a process which projects backwards and internal to the hyomandibular. Externally, however, both the hyomandibular and the metapterygoid unite. There is thus a V-shaped recess enclosed internally on the hyomandibular in this region. The dorsal end of this recess terminates in the opening through which the hyomandibularis facialis passes out from internal to the hyomandibular. After this. the nerve divides into two, a slender branch—the hyoideus facialis—entering a small foramen (*r.h.f.*) very near the distal end of the postero-ventral process of the hyomandibular, between it and the anterior edge of the pre-opercular, and a stouter branch—the mandibularis facialis—entering a large foramen (*r.m.f.*) situated ventral to that of the hyoideus facialis, between the symplectic and the pre-opercular.

Dorsally, the hyomandibular adjoins the pterotic and ventrally it unites with the metapterygoid. Its postero-ventral process passes posterior to the metapterygoid and stops a little above the dorsal tip of the symplectic from which it is separated by a strip of cartilage. The process lodges the dorsal half of the anterior edge of the pre-operculum. Internal to the pre-operculum extends the posterior articular process of the hyomandibular which gives articulation to the opercular.

The Symplectic (*sym.*) is a long roughly triangular bone extending from below the base of the postero-ventral process of the hyomandibular to very near the articular surface of the quadrate. Its lower half is situated internal to the quadrate and lies in a corresponding groove on the inner face of that bone.

The base of the triangle is situated above and the apex below. The dorsal half of the bone lies between the posterior edge of the metapterygoid and the margin of the pre-operculum. Dorso-anteriorly the symplectic gives off a small strip of bone with splints at its free edge. This strip passes internal to the metapterygoid and unites with it. Postero-ventrally also there is a longer but narrower strip which secures union with the quadrate. Above the dorsal edge of the symplectic is a small cartilaginous interspace which separates the bone from the end of the postero-ventral process of the hyomandibular. Inter-

nally, on the interspace of cartilage is a depression into which fits the dorsal head of the inter-hyal.

Between the dorsal end of the posterior edge of the symplectic and the pre-operculum is a large oval opening which transmits the ramus mandibularis facialis from the outer surface of the hyomandibular to the inner surface of the quadrate.

3. *Hyo-branchial Skeleton.*

(a) *Hyoid Cornu.*

The Hyoid Cornu, is also called the Hyo-branchial skeleton owing to its close connection with the branchial arches (**35**).

Each half of the cornu is attached posteriorly to the inner face of the postero-ventral end of the hyomandibular and anteriorly the two halves are united by the median basihyal.

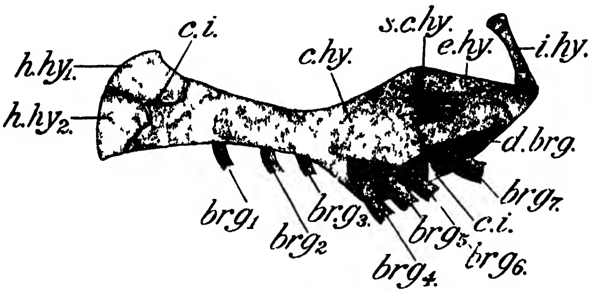

FIG 16. External view of left half of hyoid cornu. (basi-hyal omitted) (Nat. Size).

brg$_{1-7}$., the first to the seventh branchiostegals (heads only shown); *c.i.*, cartilaginous interspace (depressed); *c.hy.*, cerato-hyal; *d.brg.*, depression for attachment of branchiostegals; *e.hy.*, epi-hyal; *h.hy*$_1$., first hypohyal; *h.hy*$_2$., second hypohyal; *i.hy.*, inter-hyal; *s.c.hy.*, splints from cerato-hyal for union with epi-hyal.

The four elements that go to make up each half of the cornu are the Epihyal, the Ceratohyal, the paired Hypohyal and the Interhyal; there is then the median Basihyal.

The Epihyal (*e.hy.*) is a triangular bone occurring posterior to the ceratohyal. It is pointed posteriorly and here on the dorsal edge, slightly inwards, is a depression into which fits the proximal end of the interhyal. Anteriorly the epihyal is broad and adjoins the posterior edge of the ceratohyal. Between the ceratohyal and epihyal is a distinct interspace of cartilage whose upper half is interrupted by splints arising from the two bones and uniting with one another. On the inner face the splints are more numerous and the cartilaginous connection is scarcely visible except at its lowest end while on the outer,

the splints invest only the upper half of the cartilage the lower half being clearly visible.

Anteriorly on the lower half of its outer surface, the epihyal has a semi-oval depression which accommodates the head of the posteriormost and largest branchiostegal ray.

The epihyal, according to Allis (3) is also considered as the proximal ossification of the ceratohyal. He considers the epihyal and ceratohyal as one bone with two ossifications, a proximal and a distal.

The Ceratohyal (*c.hy.*) is a long bone, about thrice the length of the epihyal, with a very broad proximal or posterior end and narrowing, first suddenly and then gradually, towards its anterior end. Its posterior edge is curved and united to the anterior edge of the epihyal, while its dorsal and ventral edges are concave. Anteriorly, there is a dorsal indentation on the bone, which gives articulation to the upper hypohyal. The ventral half of the anterior end projects forwards and unites with the lower hypohyal. Postero-laterally, on the lower half of the bone is a small semi-oval depression to which the first six branchiostegal rays are attached by ligaments.

The Hypohyals ($h.hy._1.$, $h.hy._2.$) are two in number, a dorsal and a ventral, the former being the longer of the two. Both are triangular in shape with curved anterior edges and the apex pointing backwards. On its dorsal anterior corner the dorsal hypohyal has an articular surface which gives articulation to the posterior end of the basihyal. It is only the dorsal hypohyal that secures union with the basihyal, the ventral hypohyal being bound in the middle line to its fellow of the other side.

Separating the dorsal hypohyal from the ventral and also from the dorsal anterior edge of the ceratohyal is a distinct strip of cartilage. Such a strip does not, however, exist between the ventral hypohyal and the ceratohyal. Splints of bone arising from the hypohyals and the ceratohyal interrupt the cartilaginous lining and unite the bones with one another.

The Interhyal (*i.hy.*)—the Epihyal of Allis, also known as the stylohyal—is a short, rod-shaped bone with a flat dorsal or proximal end which fits into the depression on the cartilaginous interspace between the hyomandibular and the symplectic. Its ventral or distal end is rounded and knobby and fits into the dorso-posterior depression on the epihyal. It lies at right angles to the epihyal and is directed forwards and upwards. On its outer surface it is connected by a ligamentous sheet to the inner surface of the pre-operculum. From its proximal end there arises a ligament which passes through the foramen in the hyomandibular and is inserted on the antero-lateral corner of the sphenotic.

The Basihyal (*b.hy.*) is a thick, oval bone supporting the tongue of the fish. It is completely covered with cartilage in the fresh condition. It has a flat upper surface, a very convex

ver surface and a pointed posterior end which rests upon the rsal edges of the two upper hypohyals of the two sides, to hich it is also connected firmly by means of fibrous tissue.

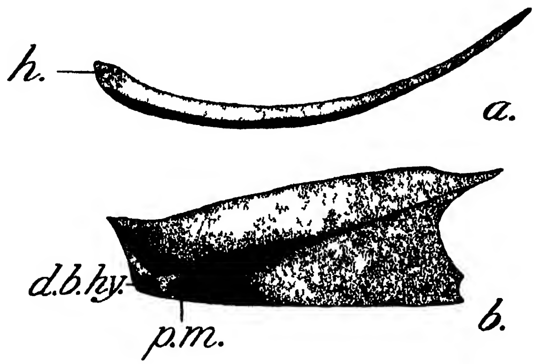

FIG. 17.

A branchiostegal bone (×1¼). b, The Uro-hyal or Basi-branchiostegal ne (×2).

.hy, depression for insertion of ligament from basi-hyal; h., head of anchiostegal for attachment to cornu; p m., point of insertion of iscles from pectoral girdle.

Connected with the hyoid cornu are two more bones which ay be dealt with here. They are, the Branchiostegals and e Urohyal or Basibranchiostegal, the latter not directly nnected to the hyoid cornu but only by ligaments and occurring tween the two cornual halves

The Branchiostegals (*brg*), which are also called the Bran- iostegal rays or Branchiosts, are seven in number, the first x attached proximally by their bases to the ventral edge of the ratohyal and the seventh to the ventral edge of the epihyal. hey are all free distally and connecting all of them is a piece the skin which forms a fold ventro-mesially along the ventral lge of the operculum. Each ray is laterally compressed with a it enlarged base and curved downwards and backwards. It pers to a point posteriorly, and possesses an ill-formed wing ong its anterior edge. The most dorsal branchiostegal which also the posteriormost ray is the longest and the rays crease in length as we proceed anteriorwards.

The two most dorsal rays lie, in the fresh condition, internal the inter-operculum, the next anterior one lies along and arallel to the ventral edge of that bone and the remaining ur rays lie on the outside, mesial to the opercular edge.

The Urohyal (*fig.* 17.*B.*)—the Sternum of Allis—or the asibranchiostegal is a roughly triangular bone lying in the

mid-ventral line between the two halves of the hyoid cornu, with a thick anterior edge, a straight dorsal edge and a slightly convex ventral edge. Starting from the ventral end of its anterior edge are two lateral laminæ, one running along the ventral margin up to about half its length and the other running backwards and upwards and ending at the dorso-posterior corner of the bone. The posterior ventral end of the bone gives insertion to ligaments that connect it to the ventral part of the anterior ends of the cleithra. From each side of its anterior end originates a ligament which is inserted on the outer lower corner of the ventral hypohyal of its side.

The Urohyal lies between the sternohyoid muscles. 'It is peculiar to the Teleostei and is generally considered to be an ossification of the median ligament' (**35**).

In close association with the Hyoid arch are the dermal bones that support the operculum. These are, the Pre-opercular, the Opercular, the Inter-opercular and the Sub-opercular.

The Pre-opercular (*p.op.*) is a crescent-shaped bone with a concave anterior edge, the concavity being directed forwards and upwards, and a convex posterior edge. The anterior edge is slightly folded on itself, the fold being external so that there is an anterior channel-like groove extending throughout that edge of the bone. Both the dorsal and the ventral ends of the bone are pointed. The dorsal half of the anterior edge lies in the groove at the posterior edge of the hyomandibular and its pointed tip extends slightly beyond the dorsal end of the groove. The ventral part of its anterior edge lies in the groove on the posterior edge of the quadrate, its pointed ventral end reaching right up to the articular surface on that bone. A small part of its anterior edge (at about the middle of its length) adjoins the interspace of cartilage between the hyomandibular and the symplectic.

The folded anterior edge forms an external flange from whose free edge five small processes of bone originate at definite distances from each other. These processes are directed backwards and downwards and their distal ends are united to the body of the pre-operculum, so that they look like definite arches arranged in a radiating manner on the bone. Passing through these arches and situated in the anterior groove of the pre-operculum is the pre-opercular lateral line canal.

On its inner surface anteriorly, slightly behind the middle of its anterior edge, the pre-operculum has a slight oval eminence which lodges in a small depression on the posterior end of the external face of the inter-operculum.

The posterior edge of the pre-operculum is markedly convex, its middle portion being bluntly pointed. The whole edge except its very dorsal part is finely serrated and into these serrations run ray-like lines starting from the middle of the bone.

e dorsal part of the posterior edge, above the bend, lies exnal to the anterior edge of the opercular. The ventral part ılmost horizontal and is parallel and external to the ventral ge of the inter-opercular.

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The anterior edge of the opercular is overlapped by the rsal part of the posterior edge of the pre-opercular and also the posterior edge of the process of the sub-opercular.

Dorso-posterior to the articulatory depression of the operar, on the inner surface of the bone, above the origin of the st opercular ridge, is a small depression for the insertion of the ator operculii.

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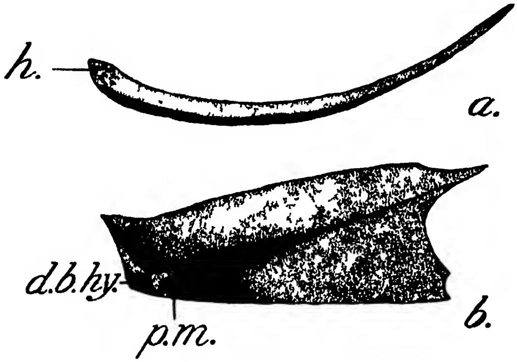

FIG. 17.

a, A branchiostegal bone (× 1¼). *b*, The Uro-hyal or Basi-branchiostegal bone (× 2).

d.l.hy., depression for insertion of ligament from basi-hyal; *h.*, head of branchiostegal for attachment to cornu; *p.m.*, point of insertion of muscles from pectoral girdle.

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On its inner surface anteriorly, slightly behind the middle of its anterior edge, the pre-operculum has a slight oval eminence which lodges in a small depression on the posterior end of the external face of the inter-operculum.

The posterior edge of the pre-operculum is markedly convex, its middle portion being bluntly pointed. The whole edge except its very dorsal part is finely serrated and into these serrations run ray-like lines starting from the middle of the bone.

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The Inter-opercular (*int.op.*) is a thick roughly oval bone lying internal to the lower half of the pre-opercular, with a posterior end that is broader than the pointed anterior end. Its dorsal edge is more or less straight, while its ventral edge is convex and possesses fine indentations on it with ray-like lines running into them. On the inner surface of its dorsal edge very near the posterior end, is a depression with a slight eminence behind it. The depression lodges the posterior end of the epihyal. The pointed anterior end of the bone is attached by ligaments to the mandibula.

The ventral edge of the inter-operculum is also united to the piece of skin which extends between all the branchiostegals and is folded in the natural condition, each fold having a branchiostegal for its axis. The two dorsalmost folds and consequently the two dorsalmost branchiostegals also, lie internal to the inter-operculum. The remaining folds are closely pressed against each other and lie mesial to the interopercular margin. The fold also narrows anteriorly according to the length of the branchiostegals, the anterior ones of which grow shorter.

The Opercular (*op.*) is a laminate, irregularly triangular bone with the apex situated antero-dorsally. This apex is thick and possesses, slightly internally, a deep socket which faces inwards and upwards and articulates with the hyomandibular. Starting from the base of the socket are two strong ridges, one of which is dorsally situated and bifurcates a little beyond its origin, the bifurcations running backwards and downwards at an angle of 25° to each other and ending in spine-like points. The second ridge which is thicker, is directed downwards and slightly backwards and forms the anterior edge of the opercular. That edge of the bone connecting the ends of these ridges is deeply concave and the ventral of the two concave edges is longer and overlaps the whole dorsal edge of the sub-opercular.

The anterior edge of the opercular is overlapped by the dorsal part of the posterior edge of the pre-opercular and also by the posterior edge of the process of the sub-opercular.

Dorso-posterior to the articulatory depression of the opercular, on the inner surface of the bone, above the origin of the first opercular ridge, is a small depression for the insertion of the levator operculii.

The Sub-opercular (*s.op.*) is a thin, leafy bone roughly oval in shape, pointed posteriorly and blunt anteriorly where it has a process with a sharp tip directed upwards and slightly forwards, and overlapped in front by the pre-opercular. The ventral edge is straight while the dorsal, which is convex, is

overlapped by the ventral edge of the operculum to which it is attached by fibrous tissue.

(b) *Branchial Arches.*

Out of the seven visceral arches, the modification and final fate of the first two have been described already. Of the remaining five, the first four support the pharyngeal wall and form a frame-work for the gills and the fifth or the last arch persists only in part as a single bone on each side, the inferior pharyngeal bone, bearing sharp teeth serving mastication.

Each branchial arch is made up of two pieces united in the mid-ventral line by the basi-branchial bone; and each half of an arch consists of four pieces; a dorsal Pharyngo-branchial, a dorsal Epibranchial, a lateral Ceratobranchial and a ventral Hypobranchial. The hypobranchials of the two sides are connected in the mid-ventral line by the median Basibranchial.

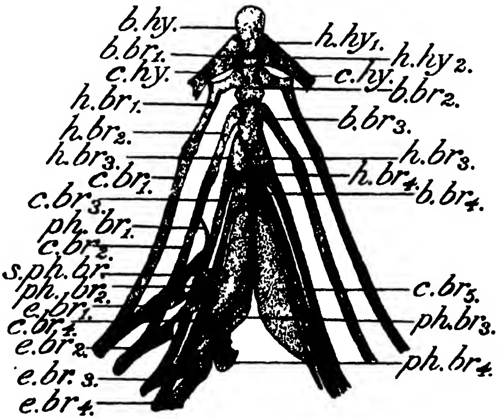

FIG. 18. Dorsal view of the Branchial Arches (Nat. Size.) (Slightly pulled out for the sake of clarity).

b.hy., basi-hyal; *b.br*$_{1-4}$., the first, second, third and fourth basi-branchials; *c.br*$_{1-4}$., the first, second, third and fourth cerato-branchials; *c.br*$_5$., the fifth cerato-branchial or inferior pharyngeal bone; *c.hy.*, cerato-hyal; *e.br*$_{1-4}$., the first, second, third and fourth epi-branchials; *h.br*$_{1-4}$., the first, second, third and fourth hypo-branchials; *h.hy*$_{1-2}$., the two hypo-hyals; *ph.br*$_{1-4}$., the first, second, third and fourth pharyngo-branchials; *s.ph.br.*, the first supra-pharyngo-branchial.

In *Otolithus* all the four branchial arches and the inferior pharyngeal bones are present and well-ossified. The first arch contains all the pieces and in addition, a small dorsal cartilaginous piece—the Supra Pharyngobranchial—; and the first basibranchial is cartilaginous. The second and third arches are

also complete in possessing all the elements. In the fourth arch the basibranchial is absent as also the hypobranchial ; but there is a median piece of cartilage existing behind the third basibranchial. A similar piece found in the same place in the branchial skeleton of *Scomber* by Allis (3) has been called by him the fused unossified hypobranchials of the fourth arch. The fifth arch is represented by the ceratobranchials which are transformed into the Inferior pharyngeal bones.

The Basibranchials : The First Basibranchial ($b.br_1$.) is a thick piece of cartilage occuring between the hypohyals and lying ventral to the posterior part of the basihyal. It is more or less triangular in shape with a blunt tip which is bent downwards. Posteriorly it is immovably connected to the second basibranchial. Ventrally its posterior edge is in apposition on either side with the ventral part of the articular head of the first hypobranchial.

The Second Basibranchial ($b.br_2$.) is a thick, well-ossified, roughly triangular bone, longer than the first and united to its hind edge. Its broad posterior edge is fused with the third basibranchial by synchondrosis. Laterally in its anterior half it has on each side a deep concavity into which the head of the first hypobranchial fits. This concavity is long and extends forwards upto the postero-ventral edge of the first basibranchial. Behind this facet the bone is broad. Its dorsal surface is flat but the ventral surface is slightly concave. Ventrally the lateral part of its posterior edge adjoins the lower part of the articular head of the second hypobranchial. No clear interspace of cartilage exists between the first and second basibranchials or between the second basibranchial and the head of the first hypobranchial.

The Third Basibranchial ($b.br_3$.) is the longest, nearly twice as long as the second with a concave ventral surface. Its outline is like that of an urn with a convex anterior edge, the neck of the urn being formed by two lateral depressions behind which the bone broadens out undergoing a sudden narrowing to a point posteriorly and imperceptibly merging into the piece of cartilage—the so-called fused fourth hypobranchials. In front it fits into the hind edge of the second basibranchial without the intermediation of any cartilage.

Into the anterior lateral depressions fit the articular heads of the second hypobranchials. The posterior part of the basibranchial is embraced, as it were, by the two hypobranchials of the third arch and is thereby hidden from view.

The Fourth Basibranchial ($b.br_4$.) : Beyond the third basibranchial there is no other ossified, basibranchial element. But in front of the closely apposed anterior ends of the inferior pharyngeal bones and occupying the angle formed by the fourth ceratobranchials, is a very small piece of cartilage similar to the one observed by Allis (3) in *Scomber*, and called by him the unossified fourth basibranchial.

The Hypobranchials: All the first four arches possess hypobranchials, the fourth pair, however, being unossified.

The First Hypobranchial ($h.br_1.$) consists of a semi-cylindrical, rod-like shank and an anterior articular head which fits into the lateral depression on the second basibranchial. Ventrally, from the head, there is a short blunt process directed mesially and passing beneath the second basibranchial and almost meeting its fellow of the opposite side in the mid-ventral line. The anterior end of the process also touches the postero-ventral part of the first basibranchial.

The shank of the bone is directed backwards and slightly outwards at an angle of about 120° with the head. It is of uniform thickness and has a shallow groove for the accommodation of the branchial blood vessel. The posterior end of the shank is capped with cartilage and articulates with the anterior end of the first ceratobranchial.

The Second Hypobranchial ($h.br_2.$) is just like the first but with a shorter shank. Both the articular head and its ventral process are shorter and broader ; in fact, the latter process is so short that it ceases to be a process at all. The head is lodged in the lateral depression on the anterior part of the third basibranchial. The ill-defined ventral process is directed anteriorly and adjoins the postero-lateral edge of the second basibranchial. Between the ventral parts of the two articular heads there is a small gap through which the truncus arteriosus passes.

The shank possesses a ventral groove which is deeper than on the first hypobranchial. The posterior end of the shank, which is furnished with a cartilaginous cap, articulates with the anterior end of the second ceratobranchial.

The Third Hypobranchial ($h.br_3.$) is a flat elongated bone with its anterior half bent ventrally. Its posterior edge is convex and the two hypobranchials touch each other at a point posteriorly in the middle line. From this point they diverge anteriorly and thus enclose between them a triangular space into which enters the posterior half of the third basibranchial. The anterior half of each third hypobranchial bends ventrally and then inwards, but the two halves do not meet in the mid-ventral line. Thus they almost completely enclose a space through which the truncus passes. The posterior convex edge is lined with cartilage and unites with the anterior end of the third ceratobranchial. It also forms the anterior boundary for the cartilaginous strip (the fourth hypobranchial of Allis) occurring posterior to it. Mesially, each third hypobranchial is united to the lateral margin of the posterior part of the third basibranchial.

The Fourth Hypobranchial ($h.br_4.$) is not distinctly present but posterior to the third hypobranchials and in the angle formed by the third ceratobranchials is a parallelogram-like cartila-

ginous strip which gives articulation to the fourth cerato-branchials postero-mesially. A similar strip of cartilage found in *Scomber* has been termed by Allis (**3**) as the fourth hypobranchial. This cartilaginous strip is also in union anteriorly with the third basibranchial.

The Ceratobranchials ($c.br._{1-4}$): The four ceratobranchials are all of them alike in structure. Each is elongated and slightly bent, the hollow of the bend being oral. It is cylindrical but has a deep groove running throughout its length. Both the ends of the ceratobranchial are capped with cartilage. The anterior end of each unites with the posterior end of its own hypo-branchials; the anterior end of the fourth ceratobranchial merely abuts against the cartilaginous strip already referred to as the fourth hypobranchial. It is broad and flattened and the mesial edges of the two anterior ends of the pair meet in the middle line behind the cartilaginous strip.

The posterior end of each ceratobranchial articulates with the epibranchial of its own arch. The third and fourth cerato-branchials are slightly more bent than the second. There is a triangular scoop in the antero-mesial part of the fourth cerato-branchial.

The Fifth Ceratobranchial or the Inferior Pharyngeal bone ($c.br_5$.) is the only representative in the adult fish of the fifth branchial arch. This is a doubly curved rod with a flat mesial dentulous process extending from its anterior end to about three-fourths of its entire length. The mesial edge of the process is convex.

The united anterior ends of the two inferior pharyngeal bones lie in contact with the posterior part of the cartilaginous fourth hypobranchial, while behind, the bones are narrow and diverge from each other.

The mesial processes which, in their anterior halves, lie closely in apposition in the middle line, bear on their concave dorsal surfaces numerous teeth of various sizes with no definite arrangement.

This toothed mesial plate of the inferior pharyngeal bone working against the dentulous, united, ventral parts of the pharyngobranchials of the first four arches, forms a very good masticatory apparatus for the fish.

The Epibranchials: As stated before, only the first four arches bear epibranchials, the last one being devoid of them. All the epibranchials are long, though not so long as the cerato-branchials. One end of an epibranchial is united to the posterior end of the ceratobranchial of its own arch and the other end is directed mesially and bears the respective pharyngobranchial. The ends of the epibranchials are capped with cartilage.

The First Epibranchial ($e.br_1$.) is a long cylindrical bone, slightly flattened and curved, the hollow of the curve being postero-mesial. It has a deep groove on its dorsal side, and

from about the middle of its length there arises a mesial, flattened, roughly triangular process. The anterior end unites with the first pharyngobranchial, the apex of the triangular mesial process bears the Supra-pharyngobranchial of the first arch and the posterior end unites with the first ceratobranchial.

The Second Epibranchial (*e.br*$_2$.) resembles the first in all respects except that it is a bit more bent and has its anterior end flattened out to a small extent. It also possesses the mesial process which however, does not carry any supra-pharyngobranchial element since the latter is absent in the second and subsequent arches. The posterior end unites with the second ceratobranchial and the anterior rests on the centre of the flattened second pharyngobranchial. The dorsal groove on the bone is deeper in this case.

The Third Epibranchial (*e.br*$_3$.) is similar to the two previous epibranchials but is shorter and has a broad anterior end. The mesial process, however, is bigger and broader and arises from the posterior half of the bone. It is directed dorsally as usual, with its apex bent slightly backwards and in close apposition with the anterior face of the mesial process of the fourth epibranchial. The dorsal groove is very shallow here.

The Fourth Epibranchial (*e.br*$_4$.) is as long as the third but bent like the second with the mesial process running the entire length of the bone almost obscuring the body. Consequently there is no dorsal groove, the margin of the blade being dorsal. The anterior end is pointed and lies in a depression in the body of the fourth pharyngobranchial. The third and fourth epibranchials are so much in apposition that they appear as one single structure.

The Pharyngobranchials. There are four pharyngobranchials, one for each of the first four arches. Each is different from the other in shape, size and structure. The third and the fourth and, to a small extent, the second also, bear teeth on their ventral surfaces. All three of them are very closely attached to one another and they form an almost united toothed structure corresponding to the inferior pharyngeal bones. They are all united together by a fleshy muscular sheet and lie *en masse* beneath the auditory capsules attached by ligaments to the ventral surface of the pro-otics.

The First Pharyngobranchial (*ph.br*$_1$.) is a tiny cylindrical rod of bone attached to the anterior end of the first epibranchial.

The Second Pharyngobranchial (*ph.br*$_2$.) is a flat triangular bone situated dorsally and connected, at about the middle of its length, to the second epibranchial. Its anterior end is free and posteriorly and mesially it is united to the lateral edge of the third pharyngobranchial. Its antero-dorsal corner gives union to the posterior end of the supra-pharyngobranchial of the first arch. Ventrally a tiny strip of its posterior corner

has an irregular row of minute teeth arranged on it, the rest of its ventral surface being smooth.

The Third Pharyngobranchial (*ph.br*$_3$.) is the largest of all the pharyngobranchials. It is roughly rectangular in shape, the two long sides of the rectangle being concave, and has a large depression on its dorsal surface. The third epibranchial unites with it at its postero-dorsal corner. Its whole lateral edge adjoins and is united with the mesial edge of the second pharyngobranchial. Its mesial edge is free but its posterior edge gives articulation to the anterior edge of the fourth pharyngobranchial.

On the ventral surface, the posterior half of the bone bears numerous backwardly directed teeth arranged very irregularly. Posteriorly, just mesial to the depression which lodges the end of the third epibranchial, is a shallower depression accommodating the anterior end of the fourth epibranchial.

The third and fourth pharyngobranchials are very closely united to each other but they are easily separable without any damage to either of them.

The Fourth Pharyngobranchial (*ph.br*$_4$.) is an irregular bone looking massive but really almost hollow. There is a large postero-dorsal U-shaped concavity with the hollow of the U directed mesially. The anterior edge of the bone is united to the posterior edge of the third pharyngobranchial and the antero-dorsal corner accommodates the ventral part of the anterior end of the fourth epibranchial. Posteriorly on the margin of the U-shaped concavity, restricted to the bend of the U, are found six ridges. These are rough and have been found to be constant in number in all the specimens examined.

The whole ventral surface of the bone bears teeth. Those on the anterior third of the bone are large, sharp and backwardly directed ; the rest are uniformly small, not clearly visible to the naked eye and giving a rough feel to that part of the bone on which they occur.

The First Supra-Pharyngobranchial (*s.ph.br.*) : On the first branchial arch, arising from the apex of the triangular mesial process of the first epibranchial, is a backwardly directed curved rod of cartilage. A similar piece of cartilage found in an identical position in the branchial skeleton of *Scomber* has been termed by Allis (3), the Supra-Pharyngobranchial. This piece of cartilage in *Otolithus* goes backwards and unites with the second pharyngobranchial on its antero-lateral corner.

The Gill-rakers and the Gill-filaments : The gill-rakers are small structures found arranged on the sides of the hypo-, epi-, and cerato-branchials of the first four branchial arches. They are rough to the touch and serve as a sieve in impeding the escape of food matter found in the water taken into the branchial chamber. Any food that may be obtained this way is retained in the pharynx and is swallowed by the fish.

The gill-rakers on the outer face of the first arch are elongated pointed structures directed forwards and upwards, while those on the inside of the first arch and on both the faces of all the other arches are small, circular, flat structures with microscopic teeth on them.

The number of gill-rakers on each bone of each arch was found to be constant in more than ten specimens. A table is given below showing the number of rakers on each of the hypo-, epi- and cerato-branchials of the four arches.

Table showing the number of Gill-rakers occuring on each component of the Branchial arches.

		I	II	III	IV	V
Hypo-branchials	Outside	3	3	3	0	0
	Inside	4	3	0	0	0
Cerato branchials	Outside	9	7	8	8	0
	Inside	7	7	8	8	0
Epi-branchials	Outside	5	4*	3	2	0
	Inside	3	4*	3	2	0

* On the second epi-branchial an extra small raker is found in some cases on both sides.

The gill-rakers are purely dermal elements and are in no way fused to the arches on which they occur. In large specimens the position of the raker is indicated by the presence of a very faint elevation on the arch.

The Gill-filaments are very slender ray-like structures arranged in two rows on each arch, one row on each side of the ventral depression on the arch which lodges the branchial blood vessel. The bases of all the filaments are fused together. The gill filaments are found on the hypo-, epi-, and cerato-branchials of each arch. They will be dealt with in greater detail under the Branchial System.

(B) *Vertebral Column.*

The Vertebral Column is composed of twenty five vertebræ which are not all alike in size or structure. It can be divided into two regions: (1) An anterior Trunk Region consisting of the first eleven vertebræ, each trunk vertebra being characterised by the possession of movable ribs, one pair on each vertebra, and (2) A posterior Caudal Region composed

of the remaining fourteen vertebræ, each of which possesses a well-developed hæmal arch and hæmal spine.

The centra of all the vertebræ are well-developed and ossified and are typically Amphicoelous. There is thus enclosed between any two vertebræ a roughly spherical space filled with notochordal tissue in the living condition. The notochord is also present as a thin strand in the notochordal canal which perforates the body of the centrum.

On the centrum of every vertebra are found certain depressions which in the fresh condition are filled with muscles and fat. As a result of the formation of these depressions ridges are formed on the body of the centrum. These ridges have been called Strengthening Ridges (Cole & Johnstone, **24**).

The vertebræ also possess articulatory surfaces namely the Prezygapophyses and the Postzygapophyses. These are always dorsal in position and arise from the base of the neural arch, the prezygapophyses anteriorly and the postzygapophyses posteriorly. The prezygapophyses of one vertebra articulate with the postzygapophyses of the preceding vertebra. The zygapophyses of the first four trunk vertebræ are not well defined.

The disposition of the neural spines of the vertebræ is as follows: erect in vertebræ 1 and 2 and inclined posteriorwards from vertebra 3 onwards, the inclination being slight at first and more marked posteriorly. The neural spines of vertebræ II to VIII are thick, broad and strong, while beyond vertebra VIII they are longer, thinner and flexible. They increase in length gradually till vertebra XIII beyond which they are of the same length in vertebræ XIV, XV and XVI; from vertebra XVII there is a gradual decrease in length. The parapophyses are developed in the last six trunk vertebræ *i.e.* from trunk vertebræ VI to XI (inclusive). They are small and rudimentary in the

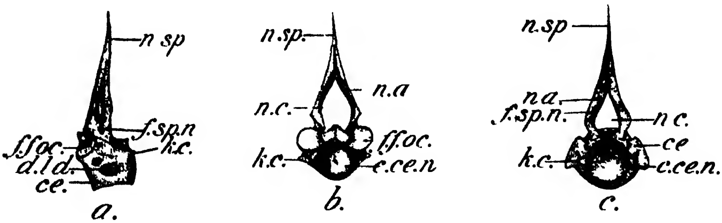

FIG. 19. The Atlas or first vertebra ($\times 1\frac{1}{3}$).

a, Side view; *b*, Anterior view; *c*, Posterior view.

c.ce.n., concavity of centrum filled with notochordal tissue; *ce.*, centrum; *d.l.d.*, dorso-lateral depression; *f.f.oc.*, facet on atlas for articulation with ex-occipital facet; *f.sp.n.*, foramen for spinal nerve; *k.c.*, lateral knob on centrum; *n.a.*, neural arch; *n.c.*, neural canal; *n.sp.*, neural spine.

sixth vertebra and show progressive development till the eleventh vertebra. They are always situated at the antero-ventral end of the centra. Except those of the sixth vertebra all the other parapophyses bear movable ribs at their free distal end. There is a pair of ribs for each vertebra, one on each parapophysis. In vertebræ I to VI the ribs are attached to the centra. There is a small thin bridge of bone connecting the two parapophyses of vertebræ IX, X and XI, that on the eleventh being broad and well developed.

The twelfth vertebra is the first caudal vertebra, for it is only here that the movable ribs cease to be present and the hæmal canal and spine are first formed in their entirety.

1. *The Trunk Vertebræ.*

A Typical Trunk Vertebra (*e.g.* Vertebra VII). There is a well-developed broad centrum typically amphicoelous, the two concavities being rather deep and communicating with each other through a narrow and minute notochordal canal which perforates the body of the centrum and persists even in the adult. In the live condition the inter-central spaces as also the notochordal canal are filled with notochordal tissue, so that the notochord is not completely lost in the adult fish.

The mid-dorsal depression on the centrum, said to be present in the vertebra of some teleostean fishes is not markedly developed here. But the mid-ventral depression is present and well-developed. On each side of the body of the centrum, laterally, there is a pair of depressions—the Dorso-lateral (*d.l.d.*) and the Ventro-lateral (*v.l.d.*). From the lateral margins of the ill-developed dorsal depression of the centrum arises a pair of processes obliquely pointing backwards, which unite dorsally to form the neural arch enclosing the neural canal through which the spinal cord passes. The neural arch (*n.a.*) is produced into a dorsal backwardly directed neural spine (*n.sp.*). The bases of the neural arch are broad and from their anterior ends is given off a pair of anteriorly and upwardly directed processes, the Prezygapophyses (*pr.z.*); there are also corresponding processes arising from the posterior ends of the bases; these are smaller and form the Postzygapophyses (*pt.z.*). The prezygapophyses are inclined forwards and upwards while the postzygapophyses point backwards and upwards. As already stated, the prezygapophyses of one vertebra articulate with the postzygapophyses of the preceding vertebra.

Arising from the anterior ends of the lateral borders of the mid-ventral groove is a pair of processes, the parapophyses (*p.p.*) one on each side. They point backwards and outwards and to the distal end of each is attached by ligaments, a pleural rib.

On the bases of the neural arch there is on each side a pair of foramina (*f.sp.n.*) for the passage of the two roots of the spinal nerve.

There are eleven trunk vertebræ each with a well-developed centrum, a neural arch, and a spine. All but the first five bear parapophyses. The zygapophyses present in all of them are developed to a varying degree in each.

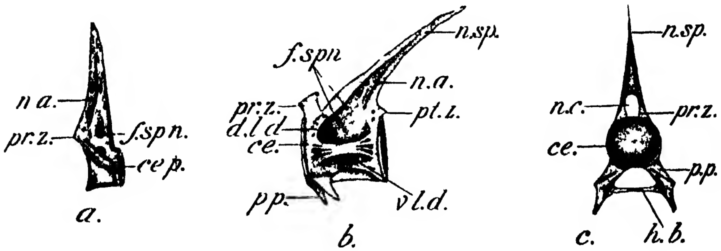

FIG. 20. Three trunk vertebrae (× 1½).

a, Side view of second trunk vertebra; *b*, Side view of seventh trunk vertebra (typical); *c*, Anterior view of last trunk vertebra.

ce., centrum; *ce.p.*, posterior part of centrum; *d.l.d.*, dorso-lateral depression; *f.sp.n.*, foramina for roots of spinal nerve; *h.b.*, horizontal bony connection; *n.a.*, neural arch; *n.c.*, neural canal; *n.sp.*, neural spine; *p.p.*, parapophysis; *pr.z.*, pre-zygapophysis; *pt.z.*, post-zygapophysis; *v.l.d.*, ventro-lateral depression.

Vertebra I has a broad centrum which is compressed antero-posteriorly, and a thick broad neural arch with a well-formed neural spine. Both the arch and the spine are erect, and the former springs up only from the anterior half of the centrum. Anteriorly, at the base of the neural arch, on each side of the centrum, is a definite well-marked flat oval surface which glides beneath the ex-occipital facet of its side at the hind end of the skull. At the junction between the body of the centrum and the base of the neural arch on each side, there is a small depression which lodges the head of the first rib. Posteriorly, from either side of the centrum a small lateral knobby eminence projects out.

Of the lateral depressions on the centrum, the dorso-lateral one is deep while the ventro-lateral is superficial and shallow. A median ventral depression is also absent. The first pair of ribs is short and bent outwards and backwards.

Vertebra II has a centrum which is more compressed than in the first vertebra. The neural arch is broad, thick, and vertical with its tip slightly curved to the front. It bears the ill-defined prezygapophyses which overlap the major part of the centrum of the first vertebra, and has at its base on each side a pair of foramina for the passage of the spinal nerve. The

breadth of the base of the neural arch exceeds that of the centrum and therefore, a part of it projects anteriorly beyond the centrum, thus indicating an ill-formed prezygapophysis. In a side view, therefore, the centrum appears pushed backwards. The posterior lateral knobby eminences found on the first vertebra are also present here and are better developed, projecting more on the sides. Articulation for the ribs is provided for as in the first vertebra, on the centrum at the junction between it and the base of the neural arch. Owing to the great compression of the centrum, the depressions are not very clear. The ribs are short and directed backwards and outwards.

Vertebra III has again a compressed centrum and a well-developed neural arch and spine, the latter fairly long and inclined backwards. The prezygapophyses are better formed than in the previous cases, projecting in front of the centrum and resting on the centrum of the second vertebra. The mid-ventral depression is shallow and its margins slightly project both anteriorly and posteriorly, suggesting the presence of rudimentary antero-ventral and postero-ventral processes. The dorso-lateral and ventro-lateral depressions are clearly present, the latter being deeper in its anterior end to accommodate the rib.

Vertebra IV has a large centrum and a strong neural arch, and a spine. The latter is inclined posteriorly and is longer than that of vertebra III. The prezygapophyses are fully formed, while the postzygapophyses are rudimentary. The ventro-lateral depression is deep specially at its anterior end where it lodges the head of the fourth rib. The ventro-median depression is fairly deep and its borders form small projections anteriorly and posteriorly as in the previous case.

Vertebra V has a longer centrum than vertebra IV. The neural arch and spine are broad and thick ; the latter is inclined posteriorly. Both the pre- and post-zygapophyses are well-defined. The dorso- and ventro-lateral depressions are deep, the latter lodging at its deeper anterior end the head of the rib. The mid-ventral depression is deep, but there are no indications of antero-ventral or postero-ventral processes.

Vertebra VI is similar to vertebra V and possesses a long centrum, and well-developed neural arch and spine and zygapophyses. The parapophyses, appearing here for the first time, are short and directed outwards, situated at the anterior ventral end of the centrum. The ribs are attached to the ventro-lateral depression as usual. Ventral median depression is quite deep, and antero-ventral and postero-ventral processes are absent.

Vertebræ VII and VIII conform to the type described.

Vertebra IX is much like vertebræ VII and VIII except that the neural spine is longer and more slender. The two parapophyses which are longer here, are connected by a thin bridge of bone, giving rise to a canal.

Vertebra X is similar to vertebra IX but with a longer neural spine. The bridge connecting the two parapophyses is better developed. The ribs are very long and directed backwards, their tips reaching up to the second caudal vertebra.

Vertebra XI is the last trunk vertebra. The parapophyses are broad and long and the connecting bridge exists; a large canal is formed in this case. The neural spine is longer and more slender than in the previous vertebra; the mid-ventral depression is broad and deep and the long ribs are directed outwards, backwards and downwards.

2. *The Caudal Vertebræ.*

There is much less variation among the vertebræ of the caudal region than among the trunk vertebræ. This region consists of fourteen vertebræ all of them alike but differing in the length of the neural and hæmal spines. The spines of the last caudal vertebra are flattened sideways and form the epural and hypural bones respectively. In all cases hæmal spines are directed backwards and lie almost parallel to the vertebral column.

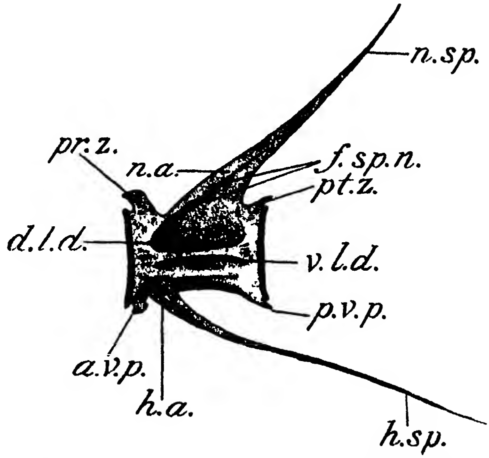

FIG. 21. A typical caudal vertebra (×2).

a.v.p., antero-ventral process; *d.l.d.*, dorso-lateral depression; *f.sp.n.*, foramina for roots of spinal nerve; *h.a.*, haemal arch; *h.sp.*, haemal spine; *n.a.*, neural arch; *n.sp.*, neural spine; *pr.z.*, pre-zygapophysis; *pt.z.*, post-zygapophysis; *p.v.p.*, postero-ventral process; *v.l.d.*, ventro-lateral depression.

A Typical Caudal Vertebra. The centrum is very well developed and long, nearly one-and-a-half times as long as that of any trunk vertebra, with clear, well-formed, dorso-lateral

and ventro-lateral depressions. The medium ventral depression is broad and deep. The neural and hæmal spines are long and directed backwards, the length of the former being about three-fourths that of the latter. The pre-and post-zygapophyses are both fully developed. The bases of the hæmal arch do not extend the whole length of the centrum, like the neural arch, but are restricted to the anterior third of it. The hæmal as well as the neural spines are grooved on the anterior and posterior faces. These grooves serve for the attachment of the sheet of ligament that connects successive spines.

Ventrally, at the anterior end, from the base of the hæmal arch spring two processes, the antero-ventral processes (*a.v.p.*), directed anteriorwards. There are similar processes, the postero-ventral processes (*p.v.p.*), on the posterior side also. The antero-ventral and postero-ventral processes of any two successive vertebræ lie merely in apposition with each other, there being no articulation between them. As in the trunk vertebra a pair

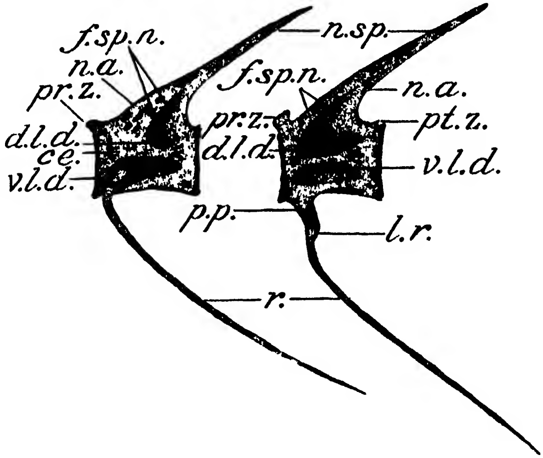

FIG. 22. Side view of two trunk vertebrae to show attachment of ribs (×2).

ce., centrum ; *d.l.d.*, dorso-lateral depression ; *f.sp.n.*, foramen for roots of spinal nerve ; *l.r.*, ligament connecting rib to parapophysis ; *n.a.*, neural arch ; *n.sp.*, neural spine ; *p.p.*, parapophysis ; *pr.z.*, pre-zygapophysis ; *pt.z.*, post-zygapophysis ; *r.*, rib ; *v.l.d.*, ventro-lateral depression.

of foramina is found on each side at the base of the neural arch for the passage of the spinal nerves.

The First Caudal Vertebra which is the twelfth vertebra of the whole series marks the commencement of the caudal region. It shows the typical condition with a broad hæmal arch but a short hæmal spine directed posteriorly almost parallel with the vertebral column. The antero-ventral processes are rudimentary but the postero-ventrals are fully formed.

Caudal Vertebra II to XII are all alike in structure. But in the twelfth caudal vertebra the neural and hæmal canals are narrow and the spines are blunt and reach the base of the caudal fin. They do not, however, take part in the support of any of the fin rays.

Caudal Vertebra XIII has a short centrum with the neural and hæmal canals occluded with bony matter. The neural and hæmal spines are flattened sideways with broad distal ends and contribute to the support of the caudal fin-rays thus forming the epural and hypural bones. Zygapophyses and ventral processes are completely absent.

The Last Caudal Vertebra is much modified in structure and it takes such a great part in the support and formation of the caudal fin that it is described along with the caudal fin skeleton.

(C) *The Ribs.*

There are eleven pairs of Pleural ribs attached to the vertebral column proximally and lying between the muscles and the peritoneum. The first six pairs are attached to the centra of the first six vertebræ, one pair on each vertebra. The ventro-lateral depressions on these trunk vertebræ are particularly deep at their anterior ends where the head of the rib is lodged. The remaining five pairs are attached to the distal ends of the parapophyses of the other five vertebræ.

The first five pairs of ribs are short and thin, while the posterior six pairs are very long and thick. The head of each rib is condensed and well-ossified and is attached by ligaments either to the centrum or to the parapophysis. Each rib is directed outwards, slightly backwards and downwards.

In addition to these pleural ribs, all the trunk vertebræ except the last, possess 'upper ribs' ('epipleurals') which occur in the horizontal septum. These 'upper ribs' are attached to the vertebræ along with the pleural ribs. They are more slender than the latter and point outwards, downwards and backwards.

(D) *The Skeleton of the Median Fins.*

The Dorsal, the Anal and the Caudal Fins form the Median Fins of the fish, since they are unpaired and occur on the median line of the body. The first two are built on the same plan and are of the same structure, the last differs from them, both in the plan of its build and the supporting structures.

1. *The Dorsal Fins.*

There are two Dorsal fins, a short anterior and a long posterior. The skeleton of both the dorsals and also the anal

fins is composed of two sets of structures and they are: (1) a regular series of bony rod-like Radials or Somactidia, endoskeletal in origin and arranged parallel to one another; and (2) the Fin-rays or Dermotrichia[1] which are dermal in origin and which support the fin.

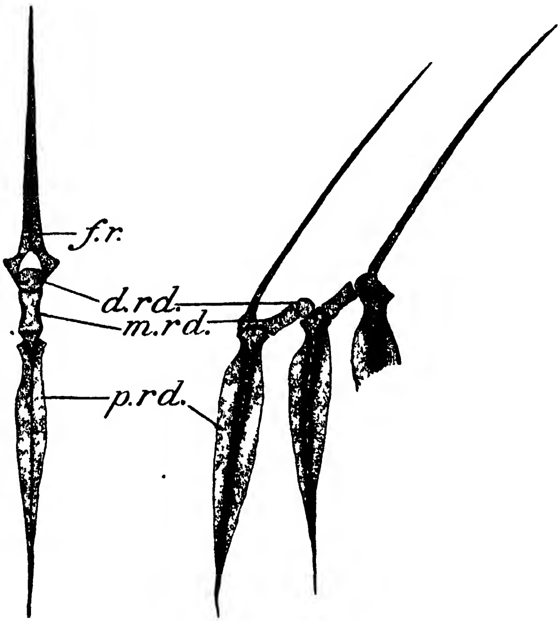

FIG. 23. Anterior and side views of radial and dermal ray of dorsal fin (× 1⅗).

d.rd., distal piece of radial; *f.r.*, fin-ray; *m.rd.*, middle piece of radial; *p.rd.*, proximal piece of radial.

[1] The Dermotrichia of fishes occur in four different kinds. They are: Ceratotrichia, Actinotrichia, Lepidotrichia and Camptotrichia.

The Ceratotrichia are slender, unjointed rods of homogeneous fibrous substances secreted by mesoblastic cells. They are found in Elasmobranchs, Holocephali and probably also in Acanthodi and Icthyotomi.

Actinotrichia are present at the edge of all the fins in the adult Teleostomes. They are unjointed, horny fibres and form the only dermotrichia in embryonic fins. They closely resemble the ceratotrichia of Elasmobranchs with which, it is possible, they are homologous. The actinotrichia develop in the mesoblastic cells below the epidermis. Only in the fatty or adipose fin of certain Teleostei (Salmonidae, Siluridae etc.) do the actinotrichia attain considerable size in the adult and form the sole organs of support.

Lepidotrichia are less numerous than the actinotrichia and are formed outside them in the more superficial mesoblastic layers. They are jointed

The radials always lie embedded within the musculature of the body and are formed in the median connective tissue septum. Those that support the dorsal and anal fins are quite similar and a description of the one holds good for the other also.

The Radial: Each radial is typically made up of three pieces. There is a large, linear or dagger-like, pointed part —the proximal piece of the radial. This is also called the Axonost or Inter-spinous bone, the latter name being given to it on account of its position between any two neural or hæmal spines. The second piece of the radial is a small cylindrical bone occurring horizontally in the median line between the distal ends of the axonost to which it belongs and the one succeeding it. This is called the Mesial piece of the radial; it is also known as the Baseost. The third or the last part of the radial is a very small cartilaginous piece occurring posterior to the mesial piece and lodged in a tiny depression on the anterior face of the distal end of the axonost succeeding the one to which it belongs. It also bears dorsally the fin ray of the next radial. Thus we find that the three parts of a radial are situated obliquely backwards from in front.

The Proximal piece of the radial (*p.rd.*) is an elongated dagger-shaped structure situated in the median septum. Its proximal end is thin, pointed and rod-like, and distally it flattens out into a broad structure with a bony head. Laterally, starting from the head and running to the proximal end is a lamina on each side of the piece serving for the attachment of the muscles controlling the movements of the fin-ray. Again, arising from the head end and directed posteriorly is a short thick cylindrical process which points slightly upwards and articulates with the proximal end of the mesial piece of the radial. On the head there is a small anterior depression to accommodate the distal piece of the preceding radial; there are also two lateral depressions, one on each side, for the reception of the two lepidotrichia constituting a fin-ray.

The whole proximal piece of the radial is flexible and transparent but the head is condensed and thick. The proximal end of the piece is connected by ligaments to the neural spines between which it occurs.

The Mesial Piece of the radial (*m.rd.*) is a cylindrical piece of bone attached proximally to the distal end of the dorsal process of the proximal piece and distally to the distal piece of the radial. It is short and directed backwards and upwards

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and branched dermal fin-rays supporting the web of both the paired and median fins of all Teleostomi.

The Camptotrichia are characteristic of the Diponi. They are jointed and usually branched fin-rays formed of a bony substance. Each camptotrichium has an unjointed proximal piece embedded in the connective tissue and muscle and a distal jointed region always covered over externally by true scales (Goodrich, 29, pages 122, 273, 212 and 232).

and is also slightly depressed in its middle portion. The Distal Piece of the radial (*d.rd.*) is a minute rod-like cartilaginous piece lodged in a depression on the succeeding axonost. Anteriorly it is connected to the distal end of the mesial piece of its radial. It usually lies clasped between the proximal ends of the two lepidotrichia of the fin-ray belonging to the next radial.

The Fin-rays (*f.r.*) show the typical condition. Each is composed of two lepidotrichia united almost throughout their length and separate only at their bases, where they diverge from each other and clasp between them the distal piece of the previous radial and also the head of the radial to which they belong and which supports them. The fin-rays are all segmented and usually unbranched, the branching starting only from about the middle of the length of the ray. In *Otolithus* the fin-rays of the first dorsal fin are unbranched.

Each fin-ray possesses a pair of slender actinotrichia at its tip, between the lepidotrichia.

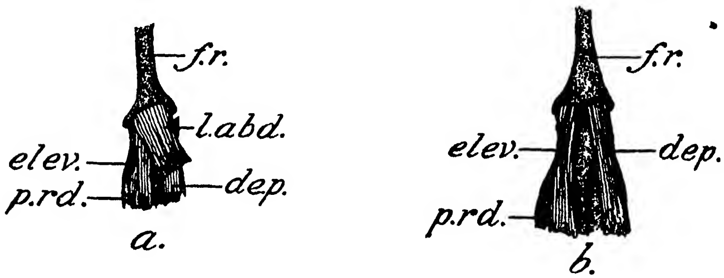

FIG. 24. Left side view of a radial and dermal ray of dorsal fin to show the muscles which work the ray ($\times 2$).

a, Showing the abductor; *b*, Abductor removed to show the elevator and depressor.

dep., depressor; *elev.*, elevator; *f.r.*, fin-ray; *l.abd.*, left abductor; *p.rd.* proximal piece of radial.

The First Dorsal Fin: The commencement of this fin is far forwards, almost on a line with the base of the pectoral fin. The fin is composed of ten rays, all of them jointed, sharp and spiny but unbranched, the first ray being short and thick. All the rays are connected together by a very thin and transparent piece of skin. These ten fin-rays are seated on nine radials the first of which bears the first two rays and the rest one each. Each radial is of the typical structure described already and is composed of the usual three pieces. The last of the nine radials, however, is represented only by the proximal and distal pieces.

The first radial is situated between the neural spines of vertebræ II and III, and the last radial between those of vertebræ

VIII and IX. The first radial is large and exhibits at its dorsal anterior part, a cleft. It bears the first ray which is small and spiny, and the second which forms the largest of the ten rays. They gradually decrease in length from the second, the last being the smallest.

The Second Dorsal Fin : This fin arises close behind the first, almost continuous with it, and ends only at the base of the caudal fin. It is made up of one strong spine and thirty branched fin-rays, all of them of nearly equal length. There are thirty radials each of the same structure as those of the first dorsal. Each bears one ray, except the first which bears in addition, the spine. The proximal piece of the first radial is situated between the neural spines of vertebræ VIII and IX, and that of the last between the neural spines of vertebræ XX and XXI. Thus it is evident that more than one proximal piece may occur between the neural spines. The last radial is devoid of the distal piece. All the axonosts bear the lateral laminæ.

The axonosts decrease in length as we proceed backwards and at the distal end of each, on either side of the lateral lamina, plenty of fat has been found to be stored and this gives a bright yellow colour to that part of the axonost and makes it stand out clearly against the white flesh.

The first spine is short and pointed, and the next fin-ray is single and unbranched, the remaining twenty-nine being clearly branched. The piece of skin connecting the fin-rays, unlike that of the first dorsal is very thick and fleshy.

2. *The Anal Fin.*

The Anal fin occurs immediately behind the anus. It is very short, but its fin-rays are large in size with numerous branches. It is made up of a large strong spine and eight fin-rays mounted on seven radials altogether. Occasionally an additional short spine is found in front of the first long one. In structure, the radials and fin-rays are quite similar to those of the dorsal fins. The proximal part of the first radial is unusually long; in fact, it is the longest axonost of any of the median fins. Its proximal end is directed upwards and forwards and at its anterior extremity it curves up and lies in close apposition with the anterior face of the hæmal spine of the thirteenth vertebra (the second caudal). The head of this axonost is thick and bears the spine, and between it and the next fin-ray is interposed a small piece of bone, very probably a basal. Further, the first axonost shows an anterior demarcation at its distal end suggesting a division of the axonost into two. The presence of the basal-like bone and the imperfect division on the first axonost suggest that it might have resulted by the fusion of two axonosts. This seems quite probable because, while in all other median fins

the number of axonosts is just one less than the number of fin-rays, in the case of the anal fin it is two less. Very likely the extra axonost which is missing has fused with the next one to form a single axonost. This suggestion is also supported by the presence of the basal piece between the spine and the fin-ray borne by the first axonost, as otherwise the presence of such a basal cannot be accounted for.

The second axonost of the anal fin is only about half the first in length. The others decrease in length from in front backwards. The last or the seventh is the smallest and is situated between the hæmal spine of vertebræ 16 and 17. As in the dorsal fins, the last radial is represented only by the proximal and middle pieces and in this case it carries the last two fin-rays.

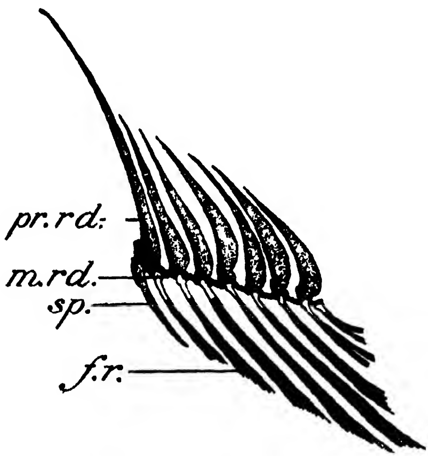

FIG. 25. The Anal fin (× 2).

f.r., fin-ray; *m.rd.*, middle piece of radial; *pr.rd.*, proximal piece of radial; *sp.*, spine of anal fin.

The piece of skin connecting the fin-rays is thick as in the second dorsal fin.

The Mechanism of the Fin-rays of the Median Fins: Each fin-ray is made up of two lepidotrichia closely united to each other except at the base where they diverge and clasp the axonost which bears them. Six muscles (in three pairs) connect the fin-ray to its axonost and these are responsible for the movements of the ray in any direction.

The first pair of muscles is very broad and short, occurring one on each side of the median line. Proximally they are connected to the skin and distally they are attached to the broad bases of the lepidotrichia of the fin-ray. These muscles are not in any way connected with the radials. Their contrac-

tion inclines the fin-ray sideways. A similar set of muscles with quite a similar action found in the Sole has been termed by Cunningham,[1] the right and left Abductors (*l.abd.*).

The other two pairs of muscles connect the fin-ray to the axonost. They are called the 'Elevators' (*elev.*) and the 'Depressors' (*dep.*) according as they elevate or depress the fin-ray in the median plane. In *Otolithus* the anterior pair forms the elevators and the posterior the depressors. There is a right elevator and a left elevator constituting the anterior pair; similarly a right and left depressor constitute the posterior pair. The elevators are attached to the axonost proximally and are inserted on the body of the axonost in front of the lateral lamina. The depressors are inserted posterior to the lamina. In other words, the elevator and depressor of one side are separated by the lateral lamina. The elevators are broader than the depressors and distally they are attached to the anterior part of the bases of the lepidotrichia, and the depressors have their attachment at the posterior part. Both the elevator and the depressor muscles of one side lie beneath and are covered by the abductor of the same side.

The axonosts are connected together by a longitudinal ligament which prevents them from hanging loose. There is also a transverse ligament which prevents a side-to-side movement of the axonost. The backwardly directed distal process of the axonost which goes to meet the mesial piece has a small cartilaginous cap, and a similar cap is provided for both the ends of the mesial piece. The internal sides of the bases of the lepidotrichia also possess a thin cartilaginous lining.

3. *The Caudal Fin.*

The Caudal Fin of *Otolithus ruber* is large and typically Homocercal.[2] The last vertebra, as already stated, is modified

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[1] Cunningham. *The Common Sole.* 1890.

[2] There are three types of caudal fin in fishes.

The most primitive type is the Protocercal (Diphycercal) where the vertebral column is continued straight into the caudal fin, the two lobes (epichordal and hypochordal) of which are thus symmetrical both externally and internally. This occurs in the Holocephali, *Polypterus* and Dipnoi and a few Selachii and Teleostei.

The next advanced type is the Heterocercal. Here the posterior end of both the notochord and the vertebral column is bent dorsalwards and the fin-rays show an asymmetrical distribution; the hypochordal lobe of the fin will be larger than the epichordal. This type shows asymmetry both externally and internally and is found in all the Elasmobranchii, Chondrostei, *Amia* and *Lepidosteus*.

A further specialised type is the Homocercal fin. This is found in the majority of the Teleostei. In this case a shortening of the vertebral axis takes place, the dorsal lobe of the fin is more suppressed and the ventral lobe better developed. The fin is symmetrical externally and asymmetrical internally.

and takes a great part in the support of the caudal fin. It is imperfectly developed and possesses only half a centrum. From the posterior end of this arise in a radiating manner two structures, flattened sideways. These are the two compound Hypural bones of the caudal fin. Each of these can be divided into three parts. The Urostyle is so constricted as not to be visible. There are two very well-developed lateral hypural spines, one on each side. Dorsal to the hypurals we get two rod-shaped bones which do not quite reach up to the vertebral column, but are connected to it by ligaments. These are the two dorsal caudal radials; the anterior of these is the longer of the two.

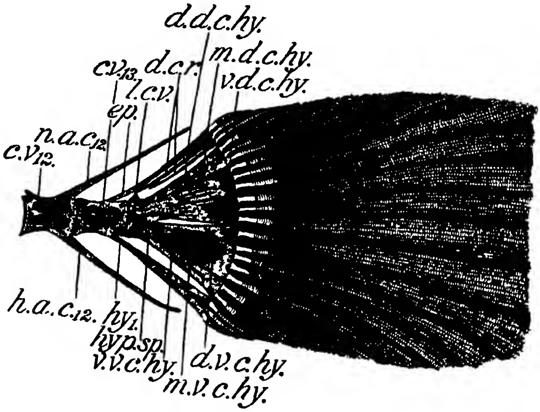

FIG. 26. Skeleton of caudal fin (Nat. Size.)

*c.v.*12. twelfth caudal vertebra; *c.v.*13., thirteenth caudal vertebra; *d.c.r.*, dorsal caudal radials; *d.d.c.hy.*, dorsal part of the dorsal compound hypural; *d.v.c.hy.*, dorsal part of the ventral compound hypural; *ep.*, epural; *h.a.c.*12., haemal arch of twelfth caudal vertebra; hy_1., first hypural; *hyp.sp.*, hypural spine; *l.c.v.*, last caudal vertebra; *m.d.c.hy.*, middle part of the dorsal compound hypural; *m.v.c.hy.*, middle part of the vertral compound hypural; *n.a.c.*12., neural arch of the twelfth caudal vertebra; *v.d.c.hy.*, ventral part of the dorsal compound hypural; *v.v.c.hy.*, ventral part of the ventral compound hypural.

The neural arch of the penultimate caudal vertebra is long and flattened and reaches up to the base of the caudal

Lastly, in some Teleostean groups (*Fierasfer, Callionymus*) the caudal fin tapers to a symmetrical end and looks like a diphycercal fin. This occurs as the result of the reduction of the tip of the heterocercal or homocercal fin in the later developing stages. Such a false or secondary diphycercal fin is called Gephyrocercal. (Goodrich—29, pp. 101, 104 and 355).

fin-rays. Thus it forms the single Epural bone (*ep.*) of the caudal fin. The hæmal arch of the same vertebra is also flattened and forms the first hypural of the caudal fin.

On the whole, therefore, we have in the caudal fin the following elements : a single epural, two dorsal caudal radials, three hypural bones (two of them being of a compound nature and capable of division into three each), two hypural spines and a very much reduced, if not insignificant, urostyle.

The epichordal lobe of the fin proper is much reduced and is made up of only three fin-rays (very rarely four or even five), all of them unbranched and borne one each by the epural and the two dorsal caudal radials. The hypochordal lobe of the fin forms the largest part of the caudal fin and consists of nineteen fin-rays. These are borne by the hypurals, and the three rays borne by the first hypural are also unbranched.

The last Caudal Vertebra is inseparably united to the caudal fin and contributes much to its formation. It is a structure which has all the features of a reduced centrum and is united to the penultimate caudal vertebra. A distinct neural arch is absent but there is a slight dorsal eminence on the centrum. Through this runs a tiny canal which seems to be a continuation of the neural canal of the preceding vertebra. In all likelihood the eminence is a vestige of the neural arch of the last vertebra. The dorsal tip of the eminence is just touched by the proximal end of the anterior dorsal caudal radial. No indication of a hæmal arch is present.

The posterior end of the last vertebra is slightly directed upwards and imperceptibly passes on into the compound hypural bones.

The Urostyle is not clear in the caudal fin.

In the caudal fin of *Otolithus* there is only one epural present. It is the modified neural arch of the penultimate caudal vertebra. According to Goodrich (**35**) it is formed by the union of a true radial with the neural spine. It is thin and rod-like, long and transparent, springing dorsally from very near the posterior end of the centrum of the penultimate vertebra and bearing at its free end a single unjointed and unbranched fin-ray, the first fin-ray of the epichordal lobe. At the base of the epural there is a tiny neural canal.

The Dorsal Caudal Radials (*d.c.r.*) are two in number, rod-shaped and occurring posterior to the epural, and connected to the vertebral column only by ligaments. The anterior one is longer and proximally it almost touches the short ill-formed neural arch of the last vertebra. At its distal end it bears only one fin-ray—the second fin-ray of the epichordal lobe. The posterior dorsal caudal radial is shorter but more flattened laterally. Distally it bears the last fin-ray of the epichordal lobe of the fin. The dorsal caudal radials are also considered as epurals by some authors.

The Hypurals are three in number the first being single and the others compound. Each compound hypural is flattened sideways with its posterior edge typically convex. Between the two compound hypurals there is a small space filled in the fresh condition with muscles.

The First Hypural (hy_1.) is a single, flattened, long bone derived according to Goodrich (**35**) by the fusion of the hæmal spine of the penultimate caudal vertebra with the corresponding radial of the caudal fin. It gradually broadens out towards its distal end where it bears three jointed but unbranched fin-rays of the hypochordal lobe. The first hypural is separated from the second which lies dorsal to it, except at the distal end where it touches the latter.

The Second Hypural is a large, fan-shaped, compound bone forming the ventral of the two compound hypurals in which the vertebral column terminates. Proximally it is connected to the posterior end of the last vertebra and distally it has a convex edge which bears the fin-rays.

At the base of the second hypural is situated the hypural spine (*hyp.sp.*) one on each side. Immediately posterior to it, on each side, is an opening through which the caudal artery passes. The openings are confluent anteriorly with the hæmal canal of the last vertebra.

The second hypural is divisible into three parts. Lines separating these three portions are clearly visible but at the proximal end they unite with the lower half of the last vertebra. For the sake of description the three parts may be termed, according to their position, dorsal, middle and ventral (*d.v.c.hy.*, *m.v.c.hy.*, and *v.v.c.hy.* respectively). The dorsal and ventral are narrow and of the same length while the middle one is nearly four times as broad as the dorsal or ventral.

The whole second hypural bears at its distal end seven of the fin-rays of the hypochordal lobe. The distribution of these seven fin-rays among the three parts of the hypural is as follows: the dorsal part carries one ray, the middle part four and the ventral part two rays.

The Third Hypural is the dorsal compound hypural. This is also large and laterally compressed and resembles a sector of a circle in shape. This also, like the second hypural, can be divided into three parts, a dorsal, a middle and a ventral (*d.d.c.hy.*, *m.d.c.hy.*, and *v.d.c.hy.* respectively). In this case the dorsal part is the narrower and the middle and ventral parts broader. Proximally the three converge and indistinguishably pass into the dorsal half of the last centrum.

The distal end of the bone is convex and bears nine fin-rays, each of the three parts carrying three rays. The dorsal part bears the first three rays of the hypochordal lobe of the caudal fin.

The Caudal Fin-rays and their Structure: As already

stated, the fin-rays are twenty-two in number. Of these, three go to form the epichordal lobe which fails to reach the extremity of the caudal fin, and the remaining nineteen form the hypochordal lobe which represents the main part of the fin. The last three fin-rays of the hypochordal lobe (borne by the ventralmost hypural) are single and unbranched and the last two alone do not reach the extremity of the fin.

Each fin-ray, like that of the dorsal or the anal fin, is paired in structure. It consists of two lepidotrichia each separable from the other longitudinally. Proximally the two lepidotrichia diverge slightly and clasp between them the cartilage-capped distal end of the epural or hypural that bears them. Distally the two lepidotrichia lie in close apposition. They are thick and round proximally and flattened out distally. In the proximal half of each ray, in the space between the two diverging lepidotrichia has been noticed a large quantity of fatty substance which gives, in the fresh condition, a yellow colour to the base of the caudal fin.

The fin-rays do not have proximal articular processes as in those of the paired fins, connecting each with its neighbour. The space between any two rays is filled up with muscles and fatty substance.

A pair of actinotrichia is present at the distal end of the fin-ray, between the two lepidotrichia.

II. Appendicular Skeleton.

The Appendicular Skeleton comprises the Pectoral girdle, the Pelvic girdle, and the Pectoral and Pelvic fins. The pectoral girdle and fins are situated far forwards immediately behind the posterior end of the operculum. The pelvic girdle and fins are situated more ventrally, in fact, on the mid-ventral line, on a level with the pectoral fins and may therefore be said to be thoracic in position.

Pectoral Girdle.

The pectoral girdle lies behind the posterior angle of the operculum. It is made up of two symmetrical halves, each being independent of the other except for the union of the tips of the two cleithra at the anterior end under the throat. The tips of the cleithra converge towards the median line and meet at the anterior end and thus abut into the angle formed by the two halves of the hyoid cornu. A ligamentous connection exists between these tips and the posterior end of the median urohyal bone.

The Pectoral girdle may be divided into 1. The Primary Girdle and 2. The Secondary Girdle. The former is endoskeletal in origin and much reduced but the latter is dermal and more prominent.

The primary girdle is made up of the Coraco-scapular elements, the Coracoid and Scapula, both of them paired, one member of each pair going to form one half of the girdle. The two halves of the primary girdle are distinct and do not meet in the middle line. The Meso-coracoidal element is absent in the pectoral girdle of *Otolithus*.

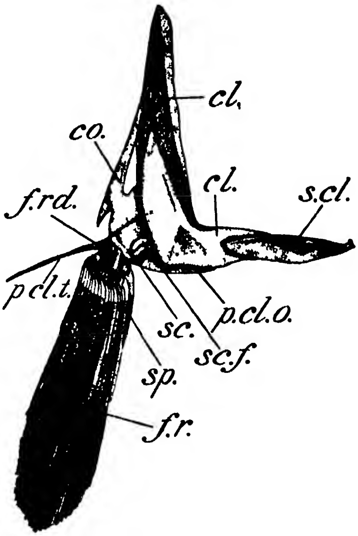

FIG. 27. External view of the left half of pectoral girdle and fin ($\times 1\frac{3}{4}$).

cl., cleithrum; *co.*, coracoid; *f.r.*, fin-ray; *f.rd.*, fin-radial; *p.cl.l.*, linear part of post-cleithrum; *p.cl.o.*, oval part of post-cleithrum; *sc.*, scapula; *sc.f.*, scapular foramen; *s.cl.*, supra-cleithrum; *sp.*, spine of pectoral fin.

The secondary girdle is similarly made up of two identical halves which, however meet in the middle line, *viz.*, the union of the two cleithral tips anteriorly. Each half of the girdle consists of the Cleithrum, a large L-shaped bone (the largest bone in the whole girdle), the Supra-cleithrum which is united to the cleithrum dorsally, the Post-temporal which connects its half of the girdle to its side of the skull, and the Post-cleithrum attached ventral to the cleithrum and possessing a cartilaginous spine-like piece directed towards the mid-ventral line.

The Primary Girdle is relatively unimportant compared to the secondary girdle. The coraco-scapular elements which comprise it are attached to the inner side of the cleithra, (the clavicles).

The Scapula (*sc.*) is a roughly oval bone with a large foramen, the scapular foramen, in its middle so that it has the shape of a ring. It is found on the inner face of the angle of the L-shaped cleithrum. Dorsally and anteriorly it secures

attachment to the cleithrum, ventrally to the coracoid, and its posterior edge bears the radials of the pectoral fin. Anteriorly a part of the scapula is overlapped by the outer lamina of the cleithrum. The posterior edge of the bone is straight and bears almost all the radials except the first which is attached to the coracoid. Along the sides of the scapula except the posterior, is a thin cartilaginous line separating the bone from the adjoining edges of the surrounding bones.

The Coracoid (*co.*) is a roughly L-shaped bone, the bend of the L being a bit rounded off. The long arm of the L is connected anteriorly to the inner lamina of the cleithrum while the short one is connected dorsally with the cleithrum and posteriorly with the scapula. The long arm is also produced beyond the angle of the L into a posteriorly directed short spiniform process. The ventral edge of the short arm bears the first radial (brachial ossicle). There is a triangular foramen in the inner lamina of the cleithrum owing to the L-shape of the coracoid. The dorsal edge of this foramen is formed of the cleithrum, the posterior by the shorter arm of the coracoid and the ventral by the long arm of the coracoid. Between the coracoid and the scapula there persists a small strip of cartilage.

The Secondary Girdle is better developed than the primary and assumes greater importance. It is made up of four bones.

The Cleithrum-(clavicle)-(*cl.*) is a large L-shaped bone. The short arm of the L is single but the long arm is folded on itself so that there is an outer lamina and an inner lamina. There is a deep groove situated in the angle formed by these two laminæ. The inner lamina has on its inner side, at the anterior end, a deep canal, the muscle canal. Dorsally also at the anterior end of the long arm, on the outer lamina, is another muscle canal. The long arm lies horizontally with its tip directed anteriorly where it unites with the tip of the cleithrum of the opposite side. The short arm lies vertically, with its tip pointing dorsally. Near its dorsal end is an external semi-oval depression which lodges the lower half of the oval supra-cleithrum. On the inner lamina of the cleithrum, immediately in front of the anterior edge of the scapula, is another well-developed muscle canal.

The Supra-cleithrum (*s.cl.*) is an oval bone with a well-developed flattened knob at the end connected with the supra-temporal. Its lower half overlaps the tip of the shorter arm of the cleithrum and its distal knobbed end is overlapped by the supra-temporal. It has a prominent strong ridge on its anterior margin.

The Post-cleithrum (*p.cl.*) is made up of two pieces, an upper oval piece and a lower linear piece which is slightly broad at its base and pointed distally. The post-cleithrum is attached to the inner side of the angle of the cleithrum by the oval part

which passes internal to the radials, while the linear piece is free and lies in the musculature directed towards the mid-ventral line.

The Post-temporal (*p.temp.*) consists of a thin, oval, expanded fan-like, posterior piece with rays, and anteriorly, two limbs, one long and pointed and the other short with a clubbed end. In fact, the fan-like piece may be said to be forked anteriorly. The long pointed limb is flat and connected by fibrous tissue to the dorsal surface of the epiotic bone at the place where the two epiotic processes start. The shorter limb is attached to the opisthotic bone, its distal tip being lodged in a small depression on the dorsal surface of that bone.

The broad leaf-like portion of the post-temporal is oval in shape and the rays which proceed from its base (wherefrom the forking begins) to the periphery. On the outer surface of the fan-like piece there are two small tunnels, obviously of the lateral line canal. On the inner surface there is a depression into which the knobby head of the supra-cleithrum fits. Very near the depression is a minute foramen. The supra-temporal overlaps the upper half of the supra-cleithrum.

Pectoral Fin.

The skeleton of the fin consists of The Radials and the Fin-Rays.

The Radials are four in number varying in size. The last ventral radial is the largest and the other three are situated dorsal to it, each smaller than the one below, so that the first of the dorsal is the smallest. Dorsal to these four is seen a small knob-like projection from the scapula. This projection bears a single fin-ray, the first one dorsally. The last or the ventral-most radial is borne at the joint between the scapula and the coracoid and the rest of the radials are borne by the posterior edge of the scapula. The coracoid thus contributes very little to the glenoid formation. The distal free ends of the radials are broad and flattened. Connecting the distal ends of all the radials is a thin cartilaginous strip to which are attached the fin-rays.

The Fin-Rays are seventeen in number. This number was found constant in half a dozen specimens that were examined. Each ray consists of two pieces—lepidotrichia—enclosing (not completely enclosing, however) a central core of soft tissue. The ray is segmented for the greater part of its length, only a small portion of the proximal end being unsegmented. The proximal ends of the two lepidotrichia diverge and clasp the cartilaginous strip already described. Each piece of the ray gives off, near the articulation to the cartilaginous piece, a downwardly directed articular process, and the two processes of each fin-ray clasp the head of the ray immediately

below it. This mechanism of one ray holding tightly the ray next below it gives the whole fin some rigidity which it would lack were the fin-rays independent of one another.

The first or the pre-axial fin-ray is unsegmented, short and spine-like with a swollen protruding head which articulates directly with the small knob of the scapula. All the other rays are long, segmented and branched and the branches may vary from two to four in number. The rays slightly decrease in length from the pre-axial to the post-axial margin of the fin.

Pelvic Girdle.

The Pelvic girdle, like the Pectoral, is made up of two similar halves. Each half of the girdle consists of a single

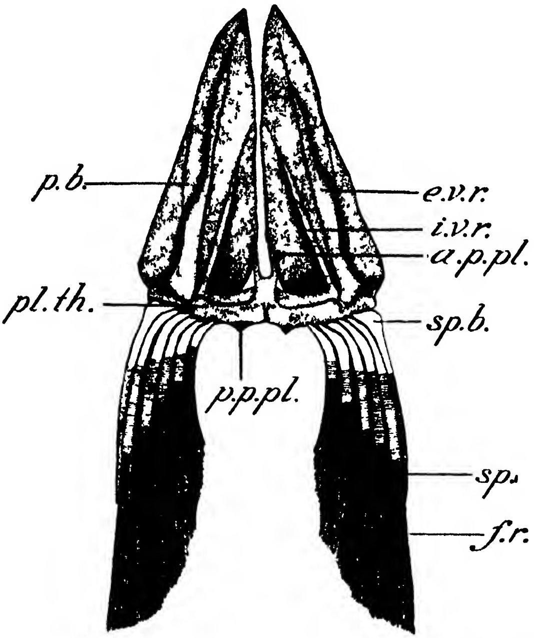

FIG. 28. Ventral view of pelvic girdle and fin (Nat. Size).

a.p.pl., anterior process of pelvic girdle ; *e.v.r.*, external ventral ridge ; *f.r.*, fin-ray ; *i.v.r.*, internal ventral ridge ; *p.b.*, pelvic bone ; *pl.th.*, posterior thickening of pelvic bone ; *p.p.pl.*, posterior process of pelvic girdle ; *sp.*, spine of pelvic fin ; *sp.b.*, enlarged base of spine.

bone, the Pelvic bone (*p.b.*), which is triangular in shape, the apex being anterior. The base of the triangle is rather short, while the other two sides are nearly twice as long as the base and meet far anteriorly at the apex. The inner margin of the

bone is at right angles to the base, and the two inner margins of the two halves of the girdle lie close together in the mid-ventral line. The base, namely, the posterior margin, is very much thickened in the form of a stout rod (*pl.th.*). There is fusion between the two thickened bases of the two halves. • It is to this thickened base that the pelvic fin-rays are attached. Ventrally, on each pelvic bone there are two large wall-like ridges which meet at the outer angle at the base of the bone, and serve for the attachment of muscles. Ventrally, from the posterior thickened part, on either side of the mid-ventral line is a small bony process directed backwards. There is a similar thin process directed forwards. The dorsal surface of the pelvic bone is quite simple except for a deep groove situated close to the outer edge, for the lodgement of muscles.

The Pelvic girdle as a whole is lodged in the angle formed by the two cleithra of the pectoral girdle and its tip is attached by ligaments to the united tips of the cleithra.

Pelvic Fin.

Radials for the support of the pelvic fins are absent in the pelvic girdle of *Otolithus*. The posterior thickened ossification on the pelvic bone serves for the attachment of the fin-rays. There are six fin-rays on the whole, constituting the pelvic fin. The first or the outermost one is very long and spine-like. The other five are segmented and branched profusely. The proximal end of each fin-ray is bifid as in the case of the pectoral fin i.e., there are two lepidotrichia going to form a fin-ray, but distally the lepidotrichia are almost inseparably united together. The lepidotrichia of a fin-ray give off proximally two inwardly directed articular processes which clasp tightly between them the base of the fin-ray immediately inner to them. This condition is similar to what obtains in the pectoral fin, giving rigidity to the fin as a whole. Distally, each ray is branched, the branches being more than twenty in some cases. The rays decrease in length as we proceed inwards.

A pair of actinotrichia occurs on each fin-ray as in those of the pectoral fin.

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ARTICLE No. 2.

Some of the Common Flowering Plants of the Hyderabad State, their distribution and economic importance.

Monocotyledons—Part I.

By M. SAYEED-UD-DIN.

CONTENTS.

INTRODUCTION.

Since the publication of my paper[1] on some of the common Dicotyledonous Flowering Plants, I have been engaged in a systematic study of the Monocotyledonous material in the collections of the Botany Department of the Osmania University. The present paper is a record of some of the Monocotyledonous plants found either wild or under cultivation in the Hyderabad Dominions. Here again, as in the last paper, I have mainly confined myself to the city environs, and Mulug—a *talukha* of the Warangal District of Hyderabad, and a Government Forest Reserve.

The arrangement of the families is in accordance with the classification adopted by Engler and Prantl in 'Der Naturlichen Pflanzenfamilien' and revised by Engler in 'Syllabus der Pflanzenfamilien'. Notwithstanding the defects of this system from the phylogenetic point of view, especially in the case of Monocotyledons, I have followed it only for the sake of a little convenience which I feel in the comparatively narrower limits, of some of the families in this system, viz. Scitamineæ of Bentham and Hooker's Classification is split up into four distinct families by Engler, *i.e.*, Musaceæ, Zingiberaçeæ, Cannaceæ, and Marantaceæ. Altogether 111 species belonging to 23 families of Monocotyledons are recorded, out of which 30 are believed to have a medicinal value and which are remarked as medicinal

[1] *JASB, Sc.*, Vol. I, 1935, p. 9.

or officinal at the end of their description. The literature cited at the end of the paper may be referred to for the medicinal properties of the plants mentioned as medicinal in this list. I have recorded a number of vernacular names of the plants, but they are not sufficient by themselves for identifying any plant. They may be advantageously used as mere clues for the determination of the species, but in every case the results must be confirmed by an examination of the plants.

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SYSTEMATIC ACCOUNT.

I. TYPHACEÆ.

1. **Typha elephantina** Roxb., *F.B.I.*, VI, p. 489.
Syn.:—*Typha angustifolia* Linn.

Vern. Name: *Tunga* (Hind.).

Habitat: Extremely common throughout the Dominions, in canals and riversides, etc.

Uses: The culms are formed into hoods by the *Coonbis* (agricultural class of villagers), to protect themselves from rain. *Tunga* is a favourite food of elephants. Medicinal.

II. PANDANACEÆ.

2. **Pandanus odoratissimus** Linn., *F.B.I.*, VI, p. 485.
(The Screw Pine.)

Vern. Names: *Keura* (Hind.); *Mogilli* (Tel.).

Habitat: Found throughout the Dominions near water-courses. Also planted in gardens.

Uses: The fragrant flowers are sold in the bazaars. They are worn in the hair by women; and are used in temples. The leaves yield an excellent fibre. Medicinal.

III. POTAMOGETONACEÆ.

3. **Potamogeton indicus** Roxb., *F.B.I.*, VI, p. 565.

Habitat : Abundant in pools, tanks, and water-courses.

IV. APONOGETONACEÆ.

4. **Aponogeton monostachyon** Linn., *F.B.I.*, VI, p. 564.

Habitat : In tanks and pools.

V. ALISMACEÆ. (ALISMATACEÆ.)

5. **Sagittaria sagittifolia** Linn., *F.B.I.*, VI, p. 561.

Habitat : Pretty common in water-holes in many parts.

Uses : The leaves are eaten as greens.

VI. HYDROCHARITACEÆ.

6. **Ottelia alismoides** Pers., *C.F.B.P.*, V, II, Pt. IV, p. 671.

Habitat : Very common in ponds and lakes, at least on the Telangana side.

7. **Hydrilla verticillata** Presl., *C.F.B.P.*, V, II, Pt. IV, p. 668.

Habitat : Commonly found in ponds and tanks.

8. **Elodea canadensis** Michx., Mayuranathan, p. 279.

Habitat : Very common in ponds and lakes. It is a native of Canada and the United States, but it is naturalized in many parts of India.

9. **Vallisneria spiralis** Linn., *C.F.B.P.*, V, II, Pt. IV, p. 669.

Habitat : Found in ponds, also grown in cisterns in gardens.

VII. GRAMINEÆ.

10. **Pennisetum typhoideum** Rich., *F.B.I.*, VII, p. 82.
(The 'Bajra' Millet.)

Vern. Name : *Bajra* (Hind.).

Habitat : Largely cultivated all over.

Uses : The grains which are much inferior to *Jawar* (*Andropogon sorghum*) are used as food by the poor classes.

11. **Panicum miliaceum** Linn., *F.B.I.*, VII, p. 45.

Vern. Name : *Worgloo* (Tel.).

Habitat : Cultivated.

12. **Panicum italicum** Roxb., *F.I.*, I, p. 302.

Vern. Name : *Rallah.*

Habitat : Cultivated towards Aurangabad side, also in the Warangal District.

Uses : The grains are a good food of pet birds.

13. **Paspalum scorbiculatum** Linn., *F.B.I.*, VII, p. 10.

Habitat : As far as I know it is not wild, but is cultivated.

14. **Saccharum officinarum** Linn., *F.B.I.*, VII, p. 118.

Vern. Names : *Nai-shakar, gunna* (Hind.).

Habitat : Not wild ; is now being extensively cultivated in the Nizamabad District with the abundant supply of water from the 'Nizam Sagar'.

Uses : Its use as the chief source of our manufactured sugar is too well known. Medicinal.

15. **Saccharum cylindricum** Lamk., Duthie—*The Fodder Grasses of North India, p.* 23.

Syn. :—*Imperata arundinacea* Cyrill.

Vern. Name : *Ban*, for cord only (Hind. local).

Habitat : Very common.

Uses : The dried culms make a strong cord known as '*ban*' with which the village cots are corded.

16. **Ischæmum pilosum** Hack., *F.B.I.*, VII, p. 130.

Vern. Name : *Kunda* (Mar.).

Habitat : A common grass of the Marhatwari side. A great pest to the cultivators.

17. **Andropogon contortus** Linn., *F.B.I.*, VII, p. 199.

Vern. Names : *Suriali, Survale-ki-ghas* (Hind.) ; *yedi* (Mar.)

Habitat : A very common grass in all places.

Uses : When green, this grass makes a good fodder for cattle.

18. **Andropogon squarrosus** Linn., *F.B.I.*, VII, p. 186.

Vern. Name : *Khas* (Hind.).

Habitat : Not very common.

Uses : The roots either alone or mixed with *Rowsa* grass are made into 'chicks' and hung in front of doors in summer. When moistened they emit a pleasant fragrant odour. A perfume is also extracted from the roots. Medicinal.

19. **Andropogon irasacusa or schoenanthus** Linn., *F.B.I.*, VII, p. 204. (The Rusa oil grass.)

Vern. Names : *Rausa*, *Rowsa* (Hind.).

Habitat : Common everywhere in open fields.

Uses : A fragrant oil is distilled from it. This grass is used with the *Khas* grass for *chicks*. Cattle fed on it are said to yield good milk. The oil is believed to have a medicinal value.

20. **Andropogon sorghum** Brot., *F.B.I.*, VII, p. 183. (The 'Juar' Millet.).

Vern. Names : *Jawar*, *Jowar*, *Jowari* (Hind.) ; *Jonna* (Tel.).

Habitat : Both the yellow and white varieties are extensively cultivated all over.

Uses : The grains form the staple food of the poor classes. The stalks with leaves known as 'Karbi' are the chief fodder for cattle.

21. **Coix lachryma** Linn., *F.B.I.*, VII, p. 100. (Job's tears.)

Habitat : Common in rice fields and marshy places. Plants were collected from a rice field in 'Mulug'.

Uses : The white glazy nuts are used as beads by some of the wandering tribes like the 'Lambadas' and the 'Banjaras' who also use them for working in embroidery on their clothes. Medicinal.

22. **Anthistiria ciliata** Linn., *F.B.I.*, VII, p. 213.

Vern. Name : *Chuneria* (Hind.).

Habitat : A common grass in pastures and forests.

Uses : Good for cattle grazing.

23. **Aristida setacea** Retz., *F.B.I.*, VII, p. 225.
(Broom grass.)

Vern. Names: *Jadoo-ka ghas* (Hind.); *Sepru-gaddi* (Tel.).

Habitat: A common grass, growing on dry open ground and on hill-sides.

Uses: Dry culms are tied up in bundles, and are used as brooms.

24. **Aristida redacta** Stapf., *F.B.I.*, VII, p. 227.

Habitat: A troublesome grass which is very common on dry soil and hill-slopes.

25. **Cynodon dactylon** Pers., *F.B.I.*, VII, p. 288.

Vern. Names: *Duba, Kali ghas, hariali* (Hind.); *Haryali* (Tel.); *Durva, Haryeli* (Mar.); *Arugam-pilla, Hariali* (Tam.).

Uses: Good for cattle grazing. It is much used for laying out lawns, etc. Medicinal.

26. **Eleusine coracana** Gærtn., *F.B.I.*, VII, p. 294.
(Ragi Millet.)

Vern. Names: *Muttengapilloo* (Tel.), *Makra* (Hind.).

Habitat: A cultivated grass.

Uses: An article of diet for the poor classes.

27. **Eleusine aegyptiaca** Desf., *F.B.I.*, VII, p. 295.

Habitat: Also cultivated.

28. **Oryza sativa** Linn., *F.B.I.*, VII, p. 92.
(The Rice plant.)

Vern. Names: *Dhan* (applied to the grains with the husk on), *Chaval* (Hind.).

Habitat: Wild in many parts of India. Partridge mentions that it is wild in Hyderabad also, but I have not seen it. Cultivated extensively towards Telangana side.

Uses: Rice is a staple food of all classes. Several savoury and sweet preparations are made of it. Light preparations as diets for invalids are made out of rice. Boiled rice, when hot, has been used for making poultice as substitute for linseed or flour. Medicinal.

29. **Bambusa arundinacea** Willd., *F.B.I.*, VII, p. 395.
(The Spiny Bamboo.)

Vern. Names: *Bans* (Hind.); *Bongu*, *Yedru* (Tel.); *Mandgai* (Mar.).

Habitat: This is the principal species in the Warangal forests, as well as in the north of Godavari, and in Amrabad.

Uses: Used in mat-making, baskets, scaffolding, etc.

30. **Dendrocalamus strictus** Nees., *F.B.I.*, VII, p. 404.
Syn. :—*Bambusa stricta* Roxb. (Male Bamboo.)

Vern. Names: *Bans* (Hind.); *Kanka*, *Yedru* (Tel.).

Habitat: Common both on the Marhatwari and on the Telangana side.

Uses: The bamboos are strong and elastic; they are usea for building purposes, baskets, and mat-making, and in the manufacture of cane furniture, etc.

31. **Zea mays** Linn., *F.B.I.*, VII, p. 102. (Maize.)

Vern. Names: *Makka*, *Makai*, *Makai-ka-bhutta* (for fruit), (Hind.).

Habitat: Cultivated all over.

Uses: The roasted fruit is nourishing and tasty. Maize meal is a valuable diet for invalids and children. Medicinal.

32. **Triticum vulgare or sativus** Vill., *F.B.I.*, VII, p. 367.

Vern. Name: *Gehoon* (Hind.).

Habitat: Cultivated more towards the Marhatwari side than towards the Telangana.

Uses: Too well-known as an article of food, etc. to be detailed here.

VIII. CYPERACEÆ.

33. **Cyperus rotundus** Linn., *F.B.I.*, VI, p. 614.

Vern. Name: *Naga-mutha* (Tel.).

Habitat: Extremely common with *Hariali* (*Cynedon dactylon*) to the extent of being a pest which is most difficult to eradicate.

Uses: The tubers are a favourite food of pigs and are supposed to be very fattening. An oil is extracted from the tubers, being used for anointing the hair.

34. **Cyperus scariosus** Br. Prodr., p. 216, *F.B.I.*, VI, p. 612.

Habitat: Common throughout.

35. **Scirpus articulatus** Linn., *F.B.I.*, VI, p. 656.

Habitat: Common on the margins of water holes.

IX. PALMÆ.

36. **Caryota urens** Linn., *F.B.I.*, VI, p. 422.

Vern. Names: *Ban-khajur* (Hind.); *Mari, Tar-mardi* (Tel.); *Berli* (Mar.).

Habitat: Frequently cultivated; often found as an escape in many places below tank bunds, viz. in Pakhal and Yellunda, etc. Widely distributed throughout India from the Sikkim Himalaya and Assam to Ceylon.

Uses: Fine fishing-lines are made from the rachis of the long spadices. The root and stem are hollowed to make buckets for water. The pith is similar to sago and makes a nutritious porridge. A large quantity of toddy is yielded by the cut spadix. The leaves yield a good fibre which is used in making ropes, brooms, etc.

37. **Borassus flabellifer** Linn., *F.B.I.*, VI, p. 482.
Syn.:—*B. flabelliformis* Linn. (Palmyra Tree.)

Vern. Names: *Tar, Tad* (Hind.); *Potu-tadi* (for male plant), *Penti-tadi* (for female plant) (Tel.); *Tad* (Mar.).

Habitat: Though a native of Tropical Africa the Palmyra palm has run wild throughout India, and especially in the Dominions it occupies vast areas of waste lands forming pure forests or intermixed with the wild date-palm. An interesting feature is that, towards Telangana side, many of these palms come out from the middle of the trunks of *Ficus bengalensis*.

Uses: Many are the uses to which this palm is put and it is one of the most important and valuable of forest trees. The chief product is 'toddy'—the sap of the cut peduncles. Government derives a good revenue from this source, and these palms are strictly preserved for this purpose. The hard outer wood is employed in making reepers, rafters, posts, etc. The trunk split longitudinally and hollowed out is used for water channels, and in making canoes. The leaves are employed in making baskets, mats, fences, fans, etc. The fibre from the leaves is used in thatching, for tying bamboos, etc. The tender fruits '*Munjal*' are eaten and are very much relished.

38. **Phoenix sylvestris** Roxb., *F.B.I.*, VI, p. 425.
(Wild Date-palm.)

Vern. Names: *Khajur, Sandola, Sendhi* (for the sap), (Hind.) ; *Leta* (Tel.) ; *Shindi* (Mar.).

Habitat: Extremely common throughout the Dominions, especially on the Telangana side, forming a gregarious forest growth for miles.

Uses: The chief product is the sap 'Sendhi' (toddy) which brings a considerable revenue to Government, and as has been stated for *Borassus* these palms are also strictly preserved under the Excise Regulations. The trunk and leaves are put to much the same uses as those of *Borassus*. The fruit which is a very inferior kind of date is eaten.

39. **Phoenix acaulis** Linn., *F.B.I.*, VI, p. 426.
(Dwarf Date-palm.)

Vern. Name: *Jangli Khajur* (Hind.).

Habitat: Not abundant. Found on dry hill-slopes, etc.

Uses: The leaves are employed for making mats, brooms, etc. The stem yields a pith-like sago. The fruit is eaten.

40. **Phoenix humilis** Royle., *F.B.I.*, VI, p. 426.

Vern. Name: *Advi eeta* (Tel.).

Habitat: Very common towards Warangal side.

41. **Phoenix dactylifera** Linn., Brandis' *Indian Trees*, p. 645.

Vern. Name: *Khajur* (Hind.).

Habitat: Cultivated to a very small extent in gardens.

Uses: The fruits are very much relished.

42. **Areca catechu** Linn., *F.B.I.*, VI, p. 405.
(Betel-nut Palm.)

Vern. Names: *Supari, Supiari* (Hind.) ; *Poka* (Tel.) ; *Pung* (Mar.).

Habitat: Commonly cultivated in gardens.

Uses: The nuts 'Supari' are chewed with betel leaves 'Pan'. The seeds are used in turnery for small ornamental work, toys, etc. The sheaths of the leaves are made into hats on the Malabar Coast.

43. Cocos nucifera Linn., *F.B.I.*, VI, p. 482.
(The Cocoa-nut Palm.)

Vern. Names: *Nariel* (Hind.); *Tenkai Kobbari* (Tel.).

Habitat: Although perhaps a native of Tropical America, the Cocoa-nut palm is cultivated in many parts of India, near the sea-side. It is cultivated to a small extent in gardens.

Uses: Too well-known to need detailed description. All parts of the plant are useful. 'Kopra' both fresh and dried is one of the important ingredients of Madrasi curries as well as those of Hyderabad. The oil is used in cooking and burning, and also for hair. It is also used in the manufacture of candles and soap.

44. Livistonia chinensis Br., *F.B.I.*, VI, p. 434.
Syn.:—*Livistonia sinensis* Mart.

Habitat: Cultivated; it is a Chinese and Japanese species.

45. Calamus rotang Linn., *F.B.I.*, VI, p. 447.
(The Rattan-cane.)

Vern. Names: *Bet*, *Bed* (Hind.); *Betam* (Tel.).

Habitat: Out of the places so far visited by me I found this only in the Warangal District, along the Moruncha Channel, below the Ramappa tank. The quality of cane is rather inferior.

Uses: Being not quite strong it is fit only for making baskets, mats, blinds, etc.

X. ARACEÆ.

46. Amorphophalus campanulatus Blume., *F.B.I.*, VI, p. 513.
Syn.:—*Arum campanulatum* Roxb., p. 629.

Vern. Names: *Zamin-khand*, *Jangli-suran* (Hind.); *Suran* (Mar.); *Kanda-gudda* (Tel.).

Habitat: Apparently wild in the Kareemnagar District of Hyderabad, and Daulatabad from where specimens were sent to me. It is also cultivated.

Uses: The corm and the seeds are used as an external application for rheumatic swellings (local information). The corm is eaten after carefully washing and heating it.

47. Pistia stratioites Linn., *F.B.I.*, VI, p. 497.
(The Water-Lettuce.)

Vern. Name: *Jal-kumbhi* (Hind.).

Habitat: Very common in standing water.

Uses: Medicinal.

48. **Pothos scandens** Linn., *F.B.I.*, VI, p. 551.

Habitat: I have not seen it wild, but it is grown in gardens and is a favourite climber.

49. **Colocasia antiquorum** Schott., *F.B.I.*, VI, p. 551.
Syn.:—*Arum Colocasia* Willd., Roxb., p. 624.

Vern. Names: *Arvi, Cham-kure-ka-gudda* (Hind.); *Chama-kura, Chama-gudda* (Tel.).

Habitat: Cultivated extensively for its tubers. Medicinal.

The following are planted in gardens:—

50. **Alocasia** sp.

51. **Aglaonema** sp.

52. **Anthurium** sp.

53. **Caladium bicolor**. There are several varieties of this species.

XI. LEMNACEÆ.

54. **Lemna polyrhiza** Linn., *C.F.B.P.*, II, Pt. V, p. 832. (Duck-weed.)

Habitat: Abundant in ponds, etc. after the rains.

55. **Wolffia michellii** Schleid., *C.F.B.P.*, II, Pt. V, p. 832.

Habitat: Minute floating plants in ponds and tanks.

XII. ERIOCAULACEÆ.

56. **Eriocaulon sieboldianum** Sieb and Zucc., *F.B.I.*, VI, p. 577.

Habitat: In wet places near ponds and canals, etc.

XIII. BROMELIACEÆ.

57. **Ananas sativus** Shult., *C.F.B.P.*, V, II, Pt. IV, p. 744. (Pine Apple.)

Vern. Name: *Anannas* (Hind.).

Habitat: Rarely cultivated here. (There are plants in the Botanic Garden, Osmania University).

Uses: Pine apple is very much relished. Vinegar is prepared, although on a very small scale from pine apples. Medicinal.

XIV. COMMELINACEÆ.

58. **Commelina subulata** Roth., *F.B.I.*, VI, p. 369.

Habitat: Common throughout. Specimens were collected from the vicinity of the Osmania University at Adigmet.

59. **Commelina benghalensis** Linn., *F.B.I.*, VI, p. 370.

Habitat: Very common everywhere. It seems to prefer rather dry situations and hard 'morum' soil. Specimens were collected at Adigmet. It possesses underground flowers.

60. **Commelina paleata** Hassk., *F.B.I.*, VI, p. 372.

Habitat: Very common. Specimens were collected from Adigmet.

61. **Cyanotis tuberosa** Schultes., *F.B.I.*, VI, p. 386.
Syn.:—*Tradescantia tuberosa* Roxb.

Habitat: Very common round about Adigmet.

Uses: Medicinal.

62. **Cyanotis axillaris** Roem and Sch., *F.B.I.*, VI, p. 388.
Syn.:—*Tradescantia axillaris* Linn.

Vern. Name: *Golagandi* (Tel.).

Habitat: As common as the preceding species.

Uses: Medicinal.

Different species of *Tradescantia* are grown in gardens, particularly *Tradescantia zebrina* for its handsome foliage.

XV. POTEDERIACEÆ.

63. **Eichhornia crassipes** Solms, Mayuranathan, p. 289.
(The Water Hyacinth.)

Syn.:—*Eichhornia speciosa* Kunth.

Habitat: A common weed in tanks and canals.

64. **Monochoria vaginalis** Presl., *F.B.I.*, VI, p. 363.
Syn.:—*Pontederia vaginalis* Linn.

Habitat: Very common in most pools and canals, etc.

Uses: Medicinal.

XVI. LILIACEÆ.

65. **Asparagus racemosus** Willd., *F.B.I.*, VI, p. 316.

Vern. Names: *Safed-musli*, *Shakakul* (Hind.); *Sima-shatavari*—for dry root (Tel.); *Shatavali* (Mar.).

Habitat: Quite common in forests, especially in the Warangal District.

Uses: Tuberous roots are pickled and shoots are eaten as vegetable by the villagers. Medicinal.

The following are cultivated as ornamental plants in gardens :—

66. **Asparagus plumosus.**

67. **Asparagus nanus.**

68. **Gloriosa superba** Linn., *F.B.I.*, VI, p. 358.

Vern. Names: *Bach-nag*. *Nat-ka-bachhnag* (Hind.); *Bisha* (Beng.); *Kartikaikishangu* (Tam.).

Habitat: Spreading rapidly towards Vikarabad side amongst bushes and in forest, also met with in the forest on the Warangal side.

Uses: The flowers are used in Hindu festivals. Medicinal.

69. **Smilax macrophylla** Roxb., *F.B.I.*, VI, p. 310.

Vern. Names: *Jungli-ushbah*, *Chobchini*, *Kamurikal* (Hind.); *Guti*, *Gutwel* (Mar.); *Malait-tamara* (Tam.); *Konda-tamara*, *Sitapu*, etc., (Tel.).

Habitat: Common in Aurangabad in the Ghat jungles, also in the Nizamabad District in forests where the author had seen it growing.

Uses: Medicinal.

70. **Smilax prolifera** Roxb., *Fl. Ind.*, III, p. 795, *F.B.I.*, VI, p. 312.

Vern. Name: *Kunda-gurvatiga* (Tel.).

Habitat: Common in most forests.

71. **Urginea indica** Kunth., *F.B.I.*, VI, p. 347.

Vern. Names: *Kanda*, *jangli-piaz* (Hind.); *Kande* (Beng.); *Ranacha-kanda* (Mar.); *Nakka-vulli-gadda* (Tel.).

Habitat: Common throughout, especially in sandy situations.

Uses: The bulbs are said to be used by Hindus in the preparation of 'ashes of silver' which is employed in medicine.

72. **Scilla indica** Baker., *F.B.I.*, VI, p. 348.

Vern. Names: *Bhui-kanda* (Hind.); *Shirunari-vengayam* (Tam.).

Habitat: Common towards Warangal side in grassy places and scrub-jungle, also towards Golkonda Fort from where the specimens were obtained.

Uses: Medicinal.

73. **Allium cepa** Linn., *F.B.I.*, VI, p. 337.
(The common Onion.)

Vern. Names: *Piyaz* (Hind.); *Vulli-gaddalu* (Tel.); *Kanda* (Mar.); *Vella-vengazam*, etc. (Tam.).

Habitat: Cultivated all over.

Uses: Onions form the chief ingredient of almost all Indian curries.

74. **Allium sativum** Linn., *F.B.I.*, VI, p. 337.
(Garlic.)

Vern. Names: *Lassun*, *Lahsun* (Hind.); *Velluli-talla-gadda* (Tel.).

Habitat: Cultivated for its economic importance.

Uses: Garlic like onion is also one of the chief ingredients of Indian curries. Medicinal.

The following are garden favourites :—

75. **Dracæna,** several species and varieties.

76. **Agapanthus umbellatus.**

77. **Frittilaria,** several species and varieties.

78. **Hemerocallis** (Dry Lily) several species and varieties.

79. **Convallaria majalis alba** (Lily of the valley).

80. **Richardia aethiopica** (Arum Lily).

81. **Asphodelus** sp.

82. **Yucca gloriosa** Linn.

XVII. AMARYLLIDACEÆ.

83. **Crinum asiaticum** Linn., *F.B.I.*, VI, p. 280.

Syn. :—*Crinum toxicarium* Roxb., *Fl. Ind.*, p. 285.

Vern. Names: *Chindar*, *Kanwal* (Hind.); *Nag-davana* (Mar.); *Bodakanod* (Beng.); *Kesar-chettu*, *Lakshminarayan chettu* (Tel.).

Habitat: Cultivated in gardens.

Uses: The fresh root is officinal in the Indian Pharmacopœia.

84. **Agave americana** Linn., *F.B.I.*, VI, p. 277.
(The American Aloe.)

Vern. Names: *Rakas patta*, *bans-keora* (Hind.); *Chagamatta*, *Changa-nara*, etc. (Tel.).

Habitat: Originally a native of America, naturalized in many parts of India, and in Hyderabad it is planted as a hedge in fields, gardens, and along railway lines and village roads, etc.

Uses: A strong fibre is obtained from the leaves. useful in rope and mat-making. Medicinal.

85. **Agave cantala** Roxb., *Fl. Ind.*, II, p. 167.

Habitat: Commonly planted as a hedge.

86. **Polianthus tuberosa** Linn., *C.F.P.B.*, II, Pt. IV, p. 753.
(Tuberose Lily.)

Habitat: A garden favourite.

The following are less commonly cultivated, but are to be found in the Botanic Garden, Osmania University:—

87. **Alstroemeria** sp.

88. **Hippeastrum** sp.

XVIII. DIOSCOREACEÆ.

89. **Dioscorea pentaphylla** Linn., *F.B.I.*, VI, p. 289.

Vern. Names: *Manda* (Mar.); *Pandigada* (Tel.).

Habitat: Very common in the 'Mulug' forests in the Warangal District from where the specimens were collected.

Uses: Medicinal.

90. **Dioscorea oppositifolia** Linn., *F.B.I.*, VI, p. 292.

Vern. Name: *Avatenga-tige* (Tel.).

Habitat: Like the preceding species very common in the 'Mulug' forests.

Uses: Medicinal.

91. **Dioscorea bulbifera** Linn., *F.B.I.*, VI, p. 296.

Vern. Names: *Zamin khand* (Hind.); *Chedu paddu dumpa* (Tel.).

Habitat: I have not seen it wild in the environs of Hyderabad, but it is said to be found towards Daulatabad, and in Kareemnagar District.

Uses: The flower spikes are cooked and eaten.

XIX. IRIDACEÆ.

The following are grown in gardens:—

92. **Iris** sp.
93. **Anomatheca** sp.
94. **Antholyza** sp.
95. **Freesia** sp.
96. **Gladiolus** sp.

97. **Crocus sativus** Linn., *F.B.I.*, VI, p. 276.

Vern. Names: *Zafran, kesar* (Hind.); *Kunkum* (Tel.).

Habitat: Native of South Europe. Cultivated in Kashmir. Several experiments were made in Hyderabad on a small scale, and some of them have been quite successful. Experiments on a bigger scale are yet to be carried out to see its prospect from the commercial point of view.

Uses: Too well known as a favourite in colouring and imparting flavour to Indian sweets and some curries. Mullahs (priests) make a kind of ink to write charms with. Medicinal.

XX. MUSACEÆ.

98. **Musa sapientum** Linn. (The Banana plant.)

Vern. Names: *Kela, Mouz* (Hind.); *Mouz, Kel* (Mar.); *Arthipundoo* (Tel.).

Habitat : Indigenous in Behar and the Eastern Himalayas, but cultivated here as in other parts of India for its fruit.

Uses : Apart from its economic use it is medicinal.

99. **Ravenala madagascariensis** Son., *F.B.I.*, VI, p. 198.
(The Traveller's tree.)

Habitat : Rarely planted in gardens (e.g. in Public gardens and in the Botanic Garden, Osmania University, and probably elsewhere also).

The following are also grown in gardens :—

100. **Musa chinensis** Sweet., *C.F.P.B.*, II, Pt. IV, p. 742.

101. **Musa ensette** J. F. Gmel., *C.F.P.B.*, II, Pt. IV, p. 721.

102. **Strelitzia reginæ** Spr. syst. 1, p. 833.

XXI. ZINGIBERACEÆ.

103. **Curcuma longa** Linn., *F.B.I.*, VI, p. 214.
(The Turmeric plant.)

Vern. Names : *Haldi* (Hind.) ; *Paspu* (Tel.) ; *Alad* (Mar.).

Habitat : Commonly cultivated for its tubers.

Uses : The powder of dry bright yellow tubers is used in all our curries. Medicinal.

104. **Zingiber officinale** Zosc., *F.B.I.*, VI, p. 246.
(The Ginger plant.)

Vern. Names : *Zangabil* (Arabic) ; *Adrak* (Hind.) ; *Sunti* (Tel.) ; *Ada* (Mar.).

Habitat : Commonly cultivated for its aromatic root-stock.

Uses : The aromatic fresh root-stock is pounded and used as a condiment in our curries. It is cut in slices and preserved in honey, and is supposed to be efficacious in excess of bile. Too well known in British and Indian Pharmacopœias to be detailed further.

105. **Costus speciosus** Smith., *F.B.I.*, VI, p. 249.

Vern. Name : *Kio* (Mar.).

Habitat : A common herb.

XXII. CANNACEÆ.

106. **Canna indica** Linn., *F.B.I.*, VI, p. 260. (Indian Shot.)

Vern. Name : *Sarvajaya* (Sans.) ; *Kardali* (Mar.).

Habitat : Not wild, but is very commonly grown in gardens as an ornamental plant.

Uses : Medicinal.

XXIII. ORCHIDACEÆ.

The following are cultivated in gardens :—

107. **Cypripedium** sp.

108. **Dendrobium** sp.

109. **Habenaria** sp.

110. **Vanda** sp.

111. **Peristeria** sp.

Although many wild epiphytic orchids have been seen and some of them collected, their identification is postponed till the actual flowers are seen.

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INDEX TO THE SCIENTIFIC NAMES.

Journal Royal Asiatic Society of Bengal. Science.
Volume II, 1936.
ARTICLE No. 3.

Further contribution to the study of the Blood Parasites of the Indian Birds, together with a list of the Hemoparasites hitherto recorded.

By I. FROILANO DE MELLO.

INTRODUCTION.

The first records on the blood parasites of the Indian birds are due to Sir Ronald Ross. From his Memoirs [1] we find that he examined the blood of pigeons, doves, paroquets, wild pigeons, finches, sparrows (*Passer indica*), crows (*Corvus splendens*), larks (*Calandretta dukhunensis*) and many of them were infected by protozoa belonging to the genus *Hæmoproteus*. Every one is aware of Sir Ronald's work on the plasmodids of sparrows and the help that such studies gave for our present knowledge of human malaria.

The book of Wenyon gives a complete list of the hæmoprotozoa of the Indian birds [2]: one can see there how small is the number of researchers who have dealt with these forms: Stephens and Christophers, Acton and Knowles,[3] Adie,[4] Plimmer[5] and H. H. Scott, the last two authors carried out their researches on birds which had died in the Zoological Gardens of London.

In the list given below (*apud* Wenyon) the parasites found by Dr. Scott are marked with the letters Z.S., just as in Wenyon where they are recorded and from where these notes are taken.

I. PLASMODIDS RECORDED IN INDIAN BIRDS.

1. *Aidemosyne malabarica*. *Pl. precox*, Z.S., 1925.
2. *Antigone virgo*. *Plasmodium* (unnamed) Z.S., 1925.
3. *Chloropsis aurifrons*. *Pl. precox*, Z.S., 1925.
4. *Corvus splendens*. *Plasmodium* (unnamed) Donovan (1908 ?).
5. *Emberiza fucata*. *Plasmodium* (unnamed) Plimmer, 1913.
6. *Eulabes religiosa* (*Gracula religiosa*). *Plasmodium* (unnamed) Plimmer, 1912 ; Z.S., 1925.
7. *Garrulax leucolophus*. *Plasmodium* (unnamed) Plimmer, 1912.
8. *Liothrix luteus*. *Plasmodium* (unnamed) Z.S., 1925.
9. *Melophus melanicterus*. *Plasmodium* (unnamed) Plimmer, 1913.

10. *Merula bulbul*. *Plasmodium* (unnamed) Plimmer, 1915.

11. *Pratincola caprata*. *Plasmodium* (unnamed) Plimmer, 1916.

12. *Pycnonotus jocosus* (*Otocompsa emeria*). *Plasmodium* (unnamed) Plimmer, 1912.

13. *Sturnus menzbieri*. *Pl. precox*, Z.S., 1925.

14. *Tragopan satyra*. *Pl. precox*, Z.S., 1925.

Remarks.—We see that whilst Plimmer only recorded the existence of a *Plasmodium* in birds, Dr. Scott (who was assisted by Dr. Wenyon) has classified as *Pl. precox* all the plasmodids found in his ornithological specimens. Studying the *Plasmodium* of *Chloropsis aurifrons davidsoni*,[6] I stated the reason why I do not agree with the classification of Dr. Scott: my *Pl. chloropsidis* which I believe to be the same as the *Pl. precox* registered by Z.S. as parasite of *Chloropsis aurifrons*, although having a general resemblance with *P. precox* Grassi and Feletti 1890, as far as it concerns the appearance of the rosettes and their irregular number of merozoites, possesses enough differential characters for maintaining its autonomy, remarkably by the compact structure of the chromatin in the nucleus of the merozoites, so totally different from the chromatinic ring which constitutes the nucleus of the real *precox* merozoites, which so often come under our observations.

The classification of bird plasmodids, the so-called *Proteosoma*, has followed many curious *étapes*: after the first period, when the species was described as autonomous according to the harbouring host, there was a tendency for grouping all bird *proteosoma* in one single species. *Pl. precox*. The fact that one single strain of avian plasmodia can infect many species of birds gives a certain support for such classification (strains of sparrow plasmodids inoculated with success in canaries, larks, goldfinches).

Shortly after, it was recognized that sparrows themselves are parasitized by more than one species of plasmodids. Hartmann[7] differentiated on morphological grounds three parasites of sparrow malaria, Russel[8] a fourth one. In this connection it is interesting to refer to a recent paper by Giovannola[9] who tries to classify the bird plasmodids in some groups, based on the following morphological characters: (*a*) the alteration of the infected cell; (*b*) the form of the schizont; (*c*) the form of the gametocyte; (*d*) the character of the pigment in the gametocyte, and (*e*) the number of the merozoites.

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To the same group belong—

Pl. capistrani Russel 1932 parasite of *Excalfactoria ineata*, immunologically different from *Pl. precox* and *Pl. cathemerium*, distinguishable only by having the pigment more abundant and constituted by large granules collected in one coniform extremity.

Pl. wasielewsky Brumpt 1909 parasite of *Athene noctua*, immunologically different from *Pl. precox* and having a smaller number of merozoites (10–12).

2nd group: Elongated gametocytes, nucleus of the parasitized red cell displaced by schizogony and slightly by gametocytes—*Pl elongatum* Huff 1930 parasite of *Passer domesticus* (Huff), and *Carduelis carduelis* (Raffæle).

3rd group: Elongated gametocytes, nucleus of the parasitized red cell never displaced. This may be divided into two subgroups: I—Sub-group with schizonts small and quadrangular. *Pl. rouxi* Sergent and Catanei 1928 parasite of *Passer domesticus* with a definite number of 4 merozoites: *Pl. tenue* Laveran and Marullaz 1914 parasite of *Liothrix luteus* (Lav. and Mar.), *Turdus merula* (Giovannola): II—Sub-group where the adult schizonts circumscribe the nucleus of the parasitized red cell; *P. circumflexum* Kikut 1931 parasite of *Turdus pilaris* (K), *Turdus iliacus* (Giovannola); *Pl. fallax* Schwetz 1930 parasite of *Syrnium nuchale* (Sch.).

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For example *Plasmodium centropi* parasite of *Centropus s. parrotti* Stresemann which we have described in a paper yet unpublished presented to the XII International Congress of Zoology held at Lisbon has: gametocytes spheroidal (1st group) and crescent shaped (2nd and 3rd group); nucleus always displaced (1st and 2nd group): pigment granular (type *precox*) and rod-shaped (type *cathemerium*). If we add to these characters, the falciform appearance of the gametocytes and the irregular appearances of the pigment, we could feel ourselves inclined to create a *fourth group* in addition to those created by Giovannola. In reality we think that, non-obstant more than

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one bird being susceptible to the infection by a given plasmodid, as can only be confirmed by inoculations and cross immunity, every bird has generally its own plasmodium and sometimes more than one, just as it happens with man and other mammifera.

* * *

To the note of the plasmodids of the Indian birds quoted above, we will add now those found in our own studies :—

15. *Herodias intermedias* Wagler.[6] *Plasmodium herodiadis, mihi*, 1935.

16. *Gallinula chloropus* L.[6] *Plasmodium gallinulæ, mihi*, 1935.

17. *Chloropsis aurifrons davidsoni* Baker.[6] *Plasmodium chloropsidis* (Scott, 1925), *mihi*, 1935.

18. *Centropus s. parrotti* Stresemann. *Plasmodium centropi* sp. nov. *mihi.*

II. Hæmoproteids recorded in Indian Birds.

Very short remarks will be made here concerning the hæmoproteids. Every one knows that the schizogonic cycle of Hæmoproteus is described according to the researches of Aragão in *Hæmoproteus columbæ* Celli and S. Felice [11] : an intracellular stage in a monocyte or endothelial cell giving rise to numerous infective small merozoites, specially found in internal organs. Studying *Hæmoproteus raymundi* parasite of *Leptocoma zeylonica* L., we have been unable to find any intracellular stage in the sections of the lungs and other organs. What we have found is a much more simple process of multiplication, consisting in the appearance of many free parasites, roundish or oval, uni- or multinucleated (we have been able to count up to 11 chromatic masses) which we interpret as free trophozoites giving by nuclear division, true rosettes resulting in merozoites or schizonts. These merozoites remain free among the red corpuscles in the interstitial spaces of the cellular trama, but never in the protoplasm of an endothelial cell or of a white mononuclear leucocyte. Sections of the spleen have also shown schizonts in the red corpuscles and free merozoites among them.[12,13]

The second point deserving attention is that concerning the so-called parthenogenetic division of the female gametocyte. Really, we sometimes find these gamonts showing two nuclear masses interpreted by some authors as the initial stage of further division. Prof. Brumpt [14] does not accept this view and explains such figures as a result of a mere fusing up, or an *accolement* of two parasites. In the course of our studies, sometimes, and specially in *Hæmoproteus sturni* [15] parasite of *Sturnus malabarica* Gemelin we have come across such *accolements*, where two male gametocytes and two female gametocytes had

their protoplasms fused together. In *Hæmoproteus glaucidii* parasite of *Glaucidium radiatum* Tickell we have even seen once one male and one female gametocyte fused together. But on the interpretation of such phenomena we prefer to keep a prudent reserve, stating for the present, that if there are evident cases where this *accolement* can be recognized, there are others where one single female gametocyte has been seen to possess two nuclei. Indeed we have not seen any figures of a further division suggesting an evident schizogony.

The last point requiring further investigation concerns the division of the female gamonts that have become free in the plasm, into two round parts · one containing the nucleus and the other devoid of any nuclear part. This has been frequently seen in *H. muruony* parasite of *Copsychus saularis* and lately in *H. raymundi*. Perhaps such phenomenon is related to some kind of sexual maturation, dividing the gamont into a true gamete (the nuclear cell) and an afertile element devoid of chromatin and containing only pigment.

List of Indian Hæmoproteids apud Wenyon.

1. *Antigone antigone*. H.Z.S., 1925.
2. *Athene brama*. H. Donovan, 1904.
3. *Caloenas nicobarica*. H.Z.S., 1925.
4. *Centropus sinensis*. H. Donovan, 1904.
5. *Chloropsis aurifrons*. H.Z.S., 1925.
6. *Cittocincla macrura*. H. Plimmer, 1914, 1917 ; Z.S., 1925.
7. *Columba livia*. H. columbæ Celli and S. Felice ant.
8. *Copsychus saularis*. *H. muruony* Mello and Sá, 1916.
9. *Coracias indica*. H. Plimmer, 1912, 1914.
10. *Corvus splendens*. H. Donovan, 1904.
11. *Dendrocitta vagabunda*. H. Plimmer, 1913.
12. *Fuligula baeri*. H. Plimmer, 1912.
13. *Garrulax albigularis*. H. Plimmer, 1913.
14. *Garrulus lanceolatus*. H. Plimmer, 1914.
15. *Glareola pratincola*. H. Plimmer, 1913.
16. *Gymnorhis flavicollis*. H. Plimmer, 1913
17. *Haliaetus leucoryphus*. H.Z.S., 1925.
18. *Maclolophus Xantogenys*. H. Plimmer 1912.
19. *Melophus melanicterus*. H. Plimmer, 1913.
20. *Mesia argentauris*. H. Plimmer, 1913.
21. *Nettopus coromandelianus*. H. Plimmer, 1915.
22. *Palæornis fasciata*. H. Plimmer, 1913.
23. *Propasser rhodochrous*. H. Plimmer, 1917.
24. *Tarrhaleus jerdoni*. H. Plimmer, 1913.

* * *

To this list we will add those found in our own studies. :—

25. *Corvus macrorhynchus*. H. Mello et alia, 1917.[16]

26. *Orthotomes sutorius*. *H. Wenyoni*. Mello et alia, 1917.[16]

27. *Machlolopus Xanthogenys*. *H. machlolopi* (Plimmer, 1912). Mello, 1935.[6]

28. *Leptocoma Zeylanica*. *H. raymundi*. Mello and Raimundo, 1934.[12, 13]

29. *Coracias b. benghalensis*. *H. coraciæ benghalensis*. Mello and Affonso, 1935.[17]

30. *Gallinula chloropus*. *H. gallinulæ*. Mello and Affonso, 1935.[15]

31. *Astur badius dussumieri*. *H. asturis dussumieri*. Mello, 1935.[15]

32. *Oriolus orilus Kundoo* *H orioli*. Mello and Rego, 1935.[15]

33. *Strix ocellata*. *H.* (unnamed). Mello, 1935.[15]

34. *Pastor roseus* *H. pastoris*. Mello, Rego and Affonso, 1935.[15]

35. *Thereiceryx Z. inornatus*. *H. thereicerycis*. Mello and Sirvoicar, 1935.[15]

36. *Thereiceryx Zeylanica*. *H. thereicerycis var. Zeylanica*. Mello, Lopes and Furtado, 1935.[15]

37. *Aegithina tiphia*. *H. ægithinæ*. Mello and Sirvoicar, 1935.[15]

38. *Centropus parrotti*. *H. centropi*. Mello, 1935.[18]

39. *Platalea leucorodia major*. *H. plataleae*. Mello, 1935.[18]

40. *Antigone virgo*. *H. antigonis*. Mello, 1935.[18]

41. *Upupa e orientalis*. *H. upupae*. Mello and Affonso, 1935.[18]

42. *Cerchneis t. objurgatus*. *H.* (*unnamed*). Mello, 1935.[18]

43 *Elanus c. vociferus*. *H. elani*. Mello and Affonso, 1935.[18]

44. *Dicrurus m. macrocercus*. *H. dicruri*. Mello, 1935.[18]

45. *Tephrodornis p. pondiceriana*. *H. tephrodornis*. Mello, 1935.[18]

46. *Otocompsa emeria*. *H. otocompsæ*. Mello and Lopes, 1935.[18]

47. *Glaucidium radiatum*. *H. glaucidii*. Mello and Lopes, 1935.[18]

48. *Sturnus malabarica*. *H. sturni*. Mello, Rivoncar and Camotim, 1935.[18]

49 *Anthus r. rufulus*. *H. anthi*. Mello and Reveredo, 1935.[18]

50. *Halcyon smyrnensis*. *H. halcyonis*. Mello and Quenim, 1935.[15]

51. *Gymnorhis Xanthocollis*. *H. gymnorhidis*. Mello and Rego, 1935.[15]

52. *Athene brama*. *H. bramæ*. Mello and Curchorcar, 1935.[15]

* * *

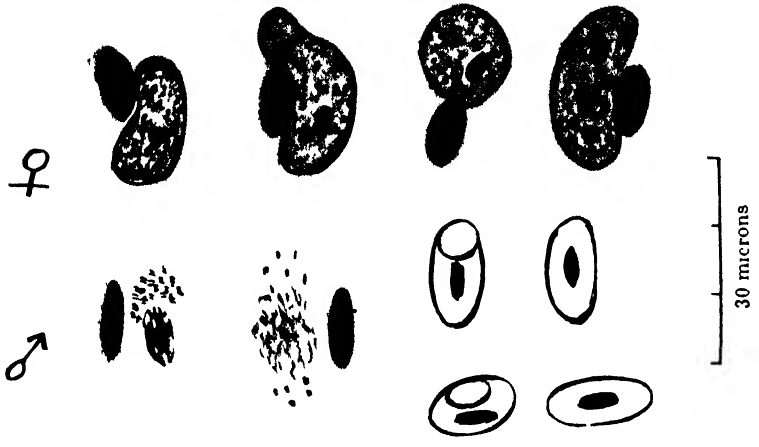


FIG. 1. Haemoproteus of *Egretta intermedia* Forster.

FIG. 2. Haemoproteus of *Lanius sch. erythronotus* Vigors.

New Hæmoproteids found during our researches.

53. *Egretta intermedia* Forster.—Shot at Salcete, identified by Mr. S. H. Prater, Curator, Bombay National History Society. *Hæmoproteus* whose gametocytes show the sexual dimorphism of this genus. *Female gametocytes* with blue protoplasm (Leishmann Stain), alveolar, often vacuolated. Nucleus oval central or sub-central. Granules of pigment of black coffee colour generally spread all over the body ; seldom collected on the centre, in some forms very scanty. Form very variable, haltheride or crescent-like, spheroidal or elliptic. We have seen some forms possessing two evident nuclei, not due to the *accolement* referred to by Brumpt and recorded also in this paper in some other Hæmoproteids. *Male gametocytes* with the protoplasm very slightly blue, generally colourless. Large nucleus without definite outline and constituted by chromatic masses which in some specimens occupy almost the whole body of the parasite. Pigment with granules located at poles, generally at both, but rarely only unipolar. One of the poles is sometimes more pigmented than the other. General form elliptical or spheroidal.

Red cell generally normal and not hypertrophied. Often deformed. Nucleus generally displaced to the periphery.

The infection of the bird was not very abundant.

Egretta intermedia Forster and *Herodias intermedias* Wagler are synonymous. Our *Hæmoproteus* is *H. herodiadis* Mello, 1935. Studied in collaboration with my pupil Fernando Lopes, it shows only slight differences : whilst the male gametocyte in our former specimen had a small central or sub-central nucleus, in this one the nucleus is large, without definite outline and occupies sometimes almost the whole body of the parasite. The distribution of the pigment being the same in both gametocytes of *H. herodiadis* differs in our actual Hæmoproteus, being all over the body in females and polar in males.

The female gametocytes of this Hæmoproteids have not shown the violet rings found in the former, but negative characters are, in such cases, not reliable for differentiation.

We consider therefore these differences mere variations in the morphology of the parasite which we identify with *Hæmoproteus herodiadis* Mello, 1935.[6]

54. *Thereiceryx viridis* Bodd.—Shot at Pondá, identified by Mr. S. H. Prater. Studied in collaboration with my pupil Narcinva V.S. Velingcar. *Hæmoproteus* with the following characters: *Female gametocyte.*—Protoplasm vacuolated, blue with Romanowsky. Small nucleus, oval or spheric, central or subcentral often situated at one pole. Its constitution is sometimes granular where one granule is often more distinct than the others (Karyosome ?). Pigment brown ochraceous, in granules scattered all over the body, often in denser clusters at the poles.

The granules have various sizes, being sometimes very minute, sometimes larger.

Form generally haltheridic.

Male gametocyte.—Slightly bluish, more generally colourless. Nucleus dust-like, sometimes very large and without definite outline, central or sub-central. Pigment in large granules generally located at the poles or along the margin. At the side of large granules there are sometimes others of more minute size.

Red cell hypertrophied. Nucleus displaced to the periphery when the parasite is somewhat grown up.

This hæmoproteus is with slight differences similar to the parasite of *Thereiceryx zeylanica* with which it will be identified. It is therefore the same as *Hæmoproteus thereicerycis var. zeylonica* Mello, Lopes and Furtado, 1935.

55. *Lanius sch. erythronotus* Vigors.—Shot at Pondá and identified by Mr. Prater of Bombay. Studied in collaboration with my pupil Narcinva S. S. Velingcar, this bird is parasitized by an *Hæmoproteus* with the following characters: *Female gametocyte* haltheridic, staining blue and with large pigment granules irregularly scattered over the body. Nucleus not staining or staining very weakly with Leishmann's stain but well with May Grunwald-Giemsa. It is small, oval or triangular and generally sub-central. *Male gametocyte*, irregular haltheride, almost quadrangular. Protoplasm colourless or very light blue. Nucleus central, large, without definite outline and constituted by chromatic masses irregularly scattered and taking sometimes the disposition of a reticulum.

Pigment granules very minute, located at poles, not abundant.

Whilst the *female gametocytes* do not alter deeply the red cells, only hypertrophying and displacing the nucleus to the periphery when the parasite is fully grown up, the male gametocyte, even when young, gives to the red cell a peculiar deformation; rendering it almost quadrangular, as it is figured in the plate.

In birds of the genus *Lanius* many *Hæmoproteids* have been recorded by the authors. So. *Lanius bucephalus* (=*Cephalophoneus bucephalus*) with a *Trypanosome* and *Hæmoproteus* studied by Ogawa in Japan 1911; *Lanius collurio* (=*Ennesctonus collurio*) with a *Trypanosome* studied by Sjöbring 1899 in Sweden, *Hæmoproteus* recorded by Ziemann 1898 in Heligoland, Wasielewsky 1908 in Germany, Wulker 1919 in Macedonia; *Trypanosome*, *Hæmoproteus*, *Leucocytozoon* and *Plasmodium* by Böing 1925, Germany; *Lanius excubitor* with a *Trypanosome* Cardamatis 1910 Greece, *Plasmodium* Schaudinn (quoted by Prowazek, 1911) Germany, *Hæmoproteus* Danielewsky 1889 South Russia, Cardamatis 1909 Greece, Brothers Sergent 1904 Algeria, Wulker 1919 Macedonia; *Trypanosome*, *Hæmoproteus*, *Leucocytozoon*, *Plasmodium* Böing 1925 Germany; *Lanius*

minor Hæmoproteus Danielewsky 1889 South Russia, Cardamatis 1909 Greece; *Lanius rufus* (=*Phoneus rutilus*) *Hæmoproteus* Danielewsky 1889 South Russia; *Lanius Schack* (=*Cephalophoneus schach*) *Hæmoproteus* Mathis and Léger 1910 Tonkin; *Lanius auriculatus* (=*Phoneus auriculatus*) *Trypanosome* A. & M. Leger 1914 Niger.

Our *Hæmoproteus* must be similar to the parasites recorded in other countries, remarkably near that of *Lanius schach* of Tonkin.

It is recorded for the first time in India, and as all these *Hæmoproteids* have not been named, we will baptize our parasite under the name *Hæmoproteus lanii*, sp. nov.

III. Leucocytozoons recorded in Indian Birds.

Some previous remarks are needed concerning the blood parasites actually classified as *Leucocytozoon*. First of all, this word, whose meaning as a generic designation has been erroneously attributed to Danielewsky, as rightly pointed out by Laveran,[18] was used by the Russian author as indicating only some unpigmented malarial parasites of birds included in cells supposed to be leucocytes. The paper of Danielewsky and its title are strongly suggestive of this statement.[19] He did not create any genus with the name *Leucocytozoon*, he spoke only of *Leucocytozoaires*, in a wide sense, referring to those parasites and their habitat according to his hypothesis.

Since then the word *Leucocytozoon* has been employed as a generic designation, but the differences of opinion on the exact meaning and nature, as well as on the cycle of these parasites and the nature of the host cell yet subsist and the problems concerning these points remain yet unsolved.

So, under the name *Leucocytozoon* are described two kinds of parasites: (*a*) the ones, elongated and contained in cells with spindle-shaped, fusiform points, the *cellules à cornes* of French authors; (*b*) the others of a round type. and whose harbouring cells never show the pointed appearances of the former.

Are they two species of parasites, or two stages of the same parasite? Wenyon[2] working with *L. neavei*, noted that 'whereas in fresh blood preparations all the parasites were in spindle shaped cells, in dried films, especially if made some time after the death of the bird, there was a much greater diversity of shape, many of the parasites being spherical while the cells appeared to have lost their tail like prolongation'.

Such is not the idea of Coles[20] who states that he has never seen the spindle-shaped Leucocytozoon and that this fact cannot be attributed to a later preparation of the blood films as they were taken at once, except perhaps in a few cases in which the bird had been dead some time, fixed by osmic acid vapour or even examined in hanging drop. 'In no case has there been any approach to the appearance of a spindle shaped body.'

Studying the Leucocytozoa of *Coracias b. benghalensis*[17] we have been fortunate enough to deal with this point. *Coracias b. benghalensis* is parasitized by both these kinds of Leucocytozoons with enough differential characters to individualize these two types and to reject the hypothesis of a possible transformation of one into another.

This autonomy of both types has not been unnoticed by other authors. Léger[21] has suggested that it would be convenient to designate these two forms under two generic different names. Unhappily his claims were founded, not on the morphology of the parasite, but on that of the host cell 'la cellule hôte est dans certains cas un *hématoblaste*, dans d'autres cas un *mononucléaire*, jamais indifféremment l'un ou l'autre'. And certainly for this reason Léger himself and Mathis wrote later on[22]; 'distinguer deux catégories de Leucocytozoon suivant la nature de la cellule hôte parasitée, ce serait, à notre avis, prématuré'.

After a long study of Leucocytozoa we maintain that these types have enough characters for constituting two genera. For the first one the name *Leucocytozoon* (genotype *Consensu unanime L. ziemanni*) should be kept, for the second one an independent genus should be created to which the name of Marcel Léger should be attached.

If we turn now our attention to the nature of the host cell, we see that the problem is far from having a solution. Léger[21] states that the host cell is sometimes an hematoblast, in other cases a mononuclear; Mathis and Léger[22] claim for the following formula : host cell fusiform-erythroblast ; host cell roundish—mononuclear leucocyte. Danilewsky who, at first, thought that the host cells were degenerated leucocytes, later on considered them as hematoblasts. Sambon agrees with Mathis and Léger; Wenyon, Keysselitz, Mayer classify such cells as erythroblasts, Laveran and Lucet believe that the L. of the Turkey is included in white cells, Woodcock thinks that *L. fringillinarum* infects a mononuclear França[21] classifies the host cell of *L. laverani* par. of *Garrulus glandarius* L. as a mononuclear leucocyte, that of the young forms of *L. mathisi* parasite of *Accipiter nisus* as an hematia. Léger finds the *L.* of *Corvus corax* in a lymphocyte, the *L. ziemanni* of *Asio accipitrinus* in an erythroblast.[23] Laveran and Marullaz[18] describe their *Hemameba liothricis* (*Leucocytozoon liothricis* apud Wenyon) in red cells.

We have not unhappily come to any definite conclusion upon this point. In *Coracias b. benghalensis* it seems that the host cell in both Leucocytozoa is of the same nature, differently deformed by the specific action of these types.

The same uncertainty prevails on the Schizogonic cycle of Leucocytozoa. The description of Fantham[24] has not been confirmed by others. Moldovan[25, 26] describes young schi-

zonts in lymphocytes or erythroblasts with 12–20, sometimes 30 nuclei (merozoites) in the organs, in acute and very heavy infections. It seems that Coles [20] has been happy enough to observe the divisional forms of the Leucocytozoon of the thrush. Such process has probably been found also by Knuth and Magdeburg in *L. anseris* in Germany. We have not worked on this point and cannot therefore give any opinion in this matter.

We will now give the list of the Leucocytozoa of the Indian birds :—

According to the list of Wenyon.

1. *Athene brama*. *Leucocytozoon* (unnamed) Donovan, 1904.
2. *Falco sp.* *Leucocytozoon* (unnamed) Donovan, 1904.
3. *Janthocincla rufigularis*. *Leucocytozoon* (unnamed) Z.S., 1925.
4. *Liothrix luteus*. *Leucocytozoon* (unnamed) Knowles, 1925.
5. *Oreicola ferrea*. *Leucocytozoon* (unnamed) Plimmer, 1913.
6. *Propasser rhodocrous*. *Leucocytozoon* (unnamed) Plimmer, 1917.

* * *

Described by me in papers already quoted and presented to the Indian Academy of Sciences :—

7. *Chloropsis aurifrons davidsoni* S. Baker (6) *Leucocytozooon chloropsidis* Mello, 1935.
8. *Coracias b. benghalensis* (L.) *Leucocytozoon coraciæ benghalensis* Mello and Affonso 1935 (of the type A. *ziemanni*), *Leucocytozoon* sp. (round type).

Described by me in collaboration with some of my pupils in a paper presented to the XII International Congress of Zoology (September, 1935) and yet unpublished :—

9. *Oriolus oriolus kundoo* Sykes. *Leucocytozoon* sp. ? Mello and Rego. Round type. Female gametocytes staining in deep blue with very small vacuoles, irregular in number. Nucleus ovoid, granular, rose. Male gametocyte with protoplasm light blue with large vacuoles, nucleus under the form of an irregular thread. It is perhaps similar to *L. anellobiæ* Cleland 1912 (Australia) parasite of *Oriolus sagittarius* (=*Mimetta sagittata*).

10. *Oriolus xanthornus xanthornus* (L.). *Leucocytozoon* sp. ? Mello. Round type. No sexual differentiation as in former

specimens. Great tendency to aberrant forms in contrast with the regular round type of *O. O. kundoo*. Nucleus either crescent like or irregular and very large in some specimens, oval with a chromatic line or point more deeply stained in others.

The very scanty infection of our bird does not allow of further remarks.

11. *Chloropsis jerdoni* Blyth. *Leucocytozoon enriquesi*, sp. nov., Mello. Round-type. It differs from *L. chloropsidis* in the following points. While in female gametocyte of *L. chloropsidis* the nucleus is roundish, or oval, rose or not stained, in *L. enriquesi* it is roundish, ovoid or sausage-shaped and always well stained. The differences in male gametocytes are much more pronounced. In *L. chloropsidis* the nucleus is long, thread-like, irregular, stained violet. In *L. enriquesi* the nucleus is very large, circular, occupying the most part of the parasite. Stained pale rose, dust-like, it is provided with a more deeply staining body, probably a Karyosome.

12. *Ardeola grayii* Sykes. *Leucocytozoon ardeolæ*, sp. nov., Mello. Round type. Protoplasm staining deep blue, more pronounced on the borders. Very minute alveoles. Nucleus circular, staining pale rose. Only five individuals seen, all of the same type and so no sexual differentiation could be made.

* * *

New Leucocytozoa found in our actual researches.

13. *Molpastes c. cafer* (L.) (in collaboration with my pupil Narcinva V. S. Velingcar).—This bird was shot at Pondá and was kindly identified by Mr. S. H. Prater, Curator, Bombay National History Society. It is parasitized by a *Leucocytozoon* of the round type which is figured in the illustration. The protoplasm of both males and females is provided with very few minute vacuoles not giving therefore any specific character for a sexual differentiation. Entirely different is the structure of the nucleus. In female gametocyte it is circular, with a well marked membrane and a conspicuous central granule (Karyosome or rather centriole). In male gametocyte it is oval, rather elliptic and the chromatin is disposed in threads giving to the endosome various appearances figured in the schematic figure *a*.

Nothing can be said about the host cell. It shows the same nuclear constitution as in other parasites of this type. It is however very curious and worthy of note that *once only* one *Leucocytozoon* has been seen, *undoubtedly included in an hematia*. We definitely make this statement. This does not mean however that the normal host cell of this parasite is an hematia. Its nuclear reliquat is entirely different from the red cell nucleus and perfectly alike to the same structures seen in other *Leucocytozoon* of this type.

FIG. 1. Leucocytozoon and Microfilaria from *Molpastes* h. haemorrhous Gmel.
(*a*) nuclei of ♂ : (*b*) sizes taken to camera lucida; (*c*) microfilaria

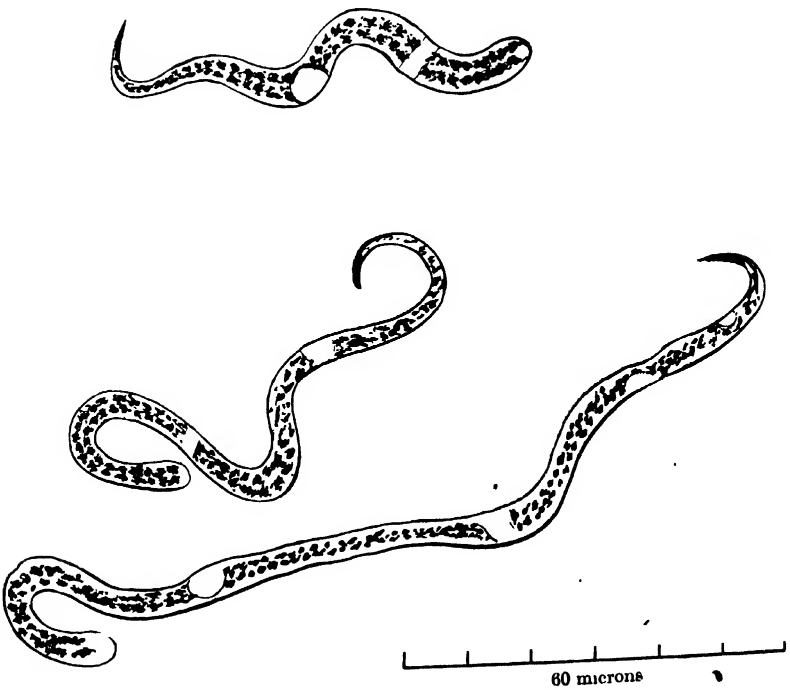


FIG. 2. Microfilarium of *Monticola solitaria pandoo* (Sykes)

No parasite has been recorded in birds of this genus. We therefore baptize our *Leucocytozoon* as *L. molpastis*, sp. nov.

IV. Trypanosomids of Indian Birds.

The bird Trypanosomes are fully dealt with in Chapter XXX of the classical work of Laveran and Mesnil.[27] Till 1903 our knowledge of these parasites was due to Danielewsky, followed by the studies of Chalachnikow. Though first described in 1888 by the former, our more precise knowledge on the trypanosome of Danielewsky (*T. avium* parasite of *Syrnium aluco*) is due to Laveran. Many birds have been found infected by Trypanosomes and some interesting facts concerning these parasites should be recorded :—

(*a*) Many birds which do not show any trypanosomes in microscopical examination, develop in the blood cultures flagellates belonging to Trypanosomids (Novy Mcneal,[28] França).

(*b*) Often the trypanosomes are found in the smears of bone marrow when the blood smears are totally negative.[29] Laveran has however found sometimes just the opposite.

(*c*) It seems also that the number of Trypanosomes in birds is subject to nychtemeral and seasonal oscillations, varying according to the species.

(*d*) The bird trypanosomes are essentially polymorphic.

List of Trypanosomes of Indian birds apud Wenyon.

1. *Athene brama*. *T. bramæ* Stephens and Crist., 1908 (Donovan, 1904).
2. *Caccabis chukar*. *T.* (unnamed) Plimmer, 1912.
3. *Cittocincla macrura*. *T.* (unnamed) Plimmer, 1914.
4. *Columba livia*. *T.* (unnamed) Hanna, 1903. Syn. *T. hannai* Mello and Sá 1916 nec Pittaluga.
5. *Copsychus saularis*. *T.* (unnamed) Plimmer, 1912, 1913 ; found by Mello and Lopes, 1935 (XII International Congress of Zoology unpublished and named *Trypanosoma moruoni* sp. n.).
6. *Corvus monedula*. *T. corvi*. Steph. and Crist., 1908.
7. *Corvus splendens*. *T.* (unnamed) Donovan, 1904.
8. *Dendrocitta vagabunda=D. rufa*. *T.* (unnamed) Plimmer, 1913.
9. *Milvus govinda*. *T. milvi*. Steph. and Christ., 1908 Donovan, 1905.
10. *Nycticorax n. nycticorax*. *T. nycticoracis* Steph. and Christ., 1908—found also by de Mello (XII Int. Congr. of Zoology, 1935).

11. *Columba sp.* *T. columbæ* Steph. and Christ., 1908 (Syn. *T.* unnamed of Hanna, *T. hannai* Mello and Sá 1916 nec Pittaluga).

* * *

Trypanosomes studied by the author and communicated to the Indian Academy of Sciences.[30]

12. *Turdoides sommervillei.* *T. turdoidis* Mello, 1935.
13. *Centropus s. parroti.* *T. centropi*, Mello, 1935.
14. *Ixobrychus m. minuta.* *T. isobrychi*, Mello, 1935.
15. *Lobivanellus i. indicus.* *T. lobivanelli* Mello, 1935.
16. *Cucullus micropternus.* *T. cuculli*, Mello, 1935.

Trypanosomes found during our actual researches.

17. *Buteo vulpinus* Gloger. *T. sp.*—This Trypanosome has been communicated to the XII International Congress of Zoology (yet unpublished). Infection very scanty, only three individuals found in five slides examined. Posterior end very pointed, rostrum like, the kinetonucleus being situated 3, 5 to 4 microns behind. It is surrounded by a very narrow vacuole, sometimes almost indistinct. Nucleus rather sub-central, circular or ovoid. Undulant membrane very visible with the axoneme taking a chromatic stain. It begins a little behind the kinetonucleus and ends in a free flagellum, very thin but distinctly visible. The whole body stains very deep with Romanowsky. Measurements of the three individuals found :—

Posterior rostrum ..	4	3, 5	4	microns
From the Kinetonucleus to the nuclear membrane ..	18	12	13	,,
Total length without the flagellum .. .	40	30	40	,,
Free flagellum .	8	6	10	,,
Breadth .. .	3	3	3, 5	,,

Novy and Meneal have described *Trypanosoma mesnili* in *Buteo lineatus* (=*Buteo desertorum*) 1905, North America, with the following measurements: length 50 microns, breadth 8, Kinetonucleus at 7 microns of the posterior point.

Our Trypanosome is much narrower than *T. mesnili*, but as the measurements of this trypanosome were taken on one single specimen and non-obstant the opinion of Novy and Meneal that in the blood of *Buteo lineatus* there is another species different trom *T. mesnili* and identified by those American authors with *T. avium* (*apud* Lav. and Mesnil), we prefer not to name our species which will be registered only as *Trypanosoma* sp.

18. *Oriolus orilus kundoo.*—During our actual researches we found in one young Oriole a trypanosome, from which only

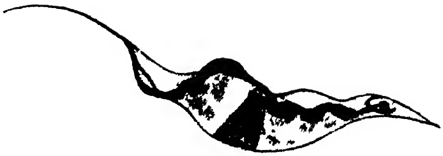
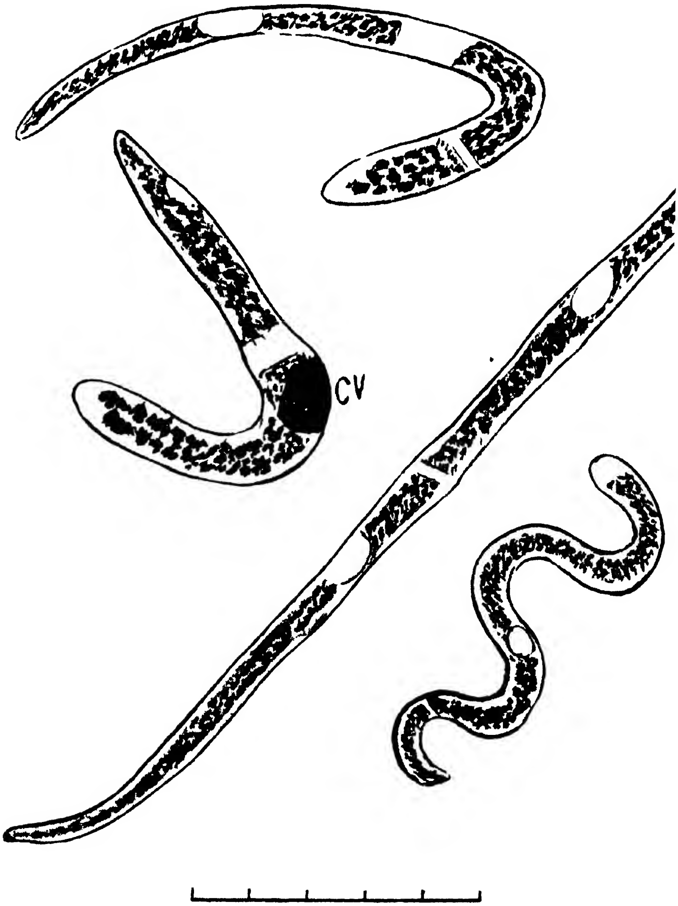


FIG. 1 Trypanosome of *Oriolus oriolus kundoo*



[illegible] of *Turdus merula nigropileus* Laf.

one specimen was seen after a long examination of three blood smears (none in lung smears). It is interesting to note that many Orioles have been examined by us since last year without showing any Trypanosomes at all.

The general morphology agrees with the avian type. Posterior extremity pointed, rostrum-like. Kinetonucleus very conspicuous, lodged in an oval vacuole. Undulating membrane, starting from the kinetonucleus and having its axoneme with a chromatic tinge. Macronucleus slightly sub-central, more towards the anterior end, and having, in the only specimen examined the form of a triangular truncated band, stained in rose by Romanowsky and of granular constitution. Free flagellum very thin but distinctly visible.

Measurements : from the posterior point to the kinetonucleus 5 microns ; from the kinetonucleus to the posterior margin of the macronucleus 12 microns ; breadth of the macronucleus 2·5 microns ; from the ant. margin to the anterior edge of the parasite 6 microns ; free flagellum 8 microns ; maximum breadth 5·5 microns.

Under the name *Trypanosoma anellobiæ* Johnston and Cleland have described a parasite of *Oriolus sagittarius* (=*Mimeta sagittata*) from Australia in 1912. As we have not found the characters of this trypanosome, we cannot identify our species which will be recorded here only as *Trypanosoma* sp

V. Toxoplasmids recorded in Indian Birds.

We are dealing now with parasites of doubtful nature whose cycle and systematic position remain yet in obscurity. The first parasites of this type in birds were described in 1911 by Beaurepaire Aragão.[31] Before them Laveran (1909) and Adie (1909) had described similar types in the sparrow and in *Padda oriziorra* which were classified by Aragão as *hemogregarines* and named by him *H. adiei* and *H. paddæ*. The parasites of the Brazilian birds were named *Hemagregarina atticoræ*, *H. ramphoceli*, *H. psoroariæ*, *H. sporophilæ*, *H. tanagræ*, *H. sicalidis*, *H. brachyspizæ* according to the bird harbouring them.

Nöller states that *Toxoplasma columbæ* Yakimoff and Kohl Yakimoff (1912) was probably the second record of this kind. Found by Carini in *Columba livia*, identified firstly with the *Toxoplasma* of dogs and rabbits, with which they have a great resemblance, later on found as a spontaneous parasite of pigeons. Yakimoff and Kohl Yakimoff gave it the specific name *Toxoplasma columbæ*.[32]

In India I found a parasite in the monocytes of pigeons, which I named *Leucocytogregarina françæ*, referred by Nöller and by Wenyon to *Toxoplasma columbæ*. I recorded schizogony in

hepatic cells, more rarely in peripheral blood and bone marrow and at the same time a definite binary division where rudimentary kariokinetic figures could be demonstrated.

According to Wenyon, Hoare who has described a typical leucocytic hemogregarine in an Indian eagle (*H. adiei*), studying Aragão's description and examining his figures, believes that in all probability five of Aragão's birds actually harboured hemogregarines, while two (*Sporophila albigularis* and *Sicalis flaveola*) harboured true toxoplasmata. Wenyon (2, page 1086) adds: 'Aragão described a number of hemogregarines from South American birds. It has been assumed by Nöller and others that he was really dealing with toxoplasmata. The discovery by Adie on an undoubted hemogregarine in an Indian eagle led Hoare to study Aragão's paper. It was found that Aragão was probably dealing with two distinct types of parasites—toxoplasmata in two birds and hemogregarines in five. The parasite of the Indian eagle which was named *Hepatozoon adiei* closely resembles the leucocytic parasites of the dog, rat and other animals and it is probable that in five of his birds Aragão was dealing with a similar organism.'

Studying carefully the paper of Aragão we are absolutely convinced that all his seven parasites belong to the same type. All have the same morphology. If the differences pointed by Hoare and Wenyon are based on the schizogonic figures of *H. sicalidis* and *H. sporophilæ*, such figures are also seen in *H. brachispizæ* (Aragão's fig. 76), although not in such an advanced stage as in the former.

What is the systematic position of these parasites? The expression *Leucocytogregarina* Porter, used in generic sense by Sangiorgi (1912) for *L. musculi* which was recognized afterwards to be an *Hepatozoon* Miller 1908, has been rejected and it is generally accepted that the bird parasites we are referring to should be classified as *Toxoplasma* Nicolle Manceaux 1908, as claimed by Nöller. One must not forget that in *T. gondii*, the type species, Nicolle and Manceaux have described a paranuclear body, attached to the nucleus which is missing in the bird parasites.

The systematic position of these bird parasites is therefore very obscure: hemogregarines for Aragão, toxoplasmata for Marullaz, Nöller and others. Nöller has advanced another hypothesis after studying a so-called toxoplasm found in the spleen and liver of *Chrysomitris spinus* L.: that they may be merozoites of Coccidia inhabiting the intestine of this bird which was infected by male and female gametocytes and also by schizonts of an *Eimeria*. The schizonts occurred in the subepithelial tissues, together with merozoites and were also traced in the lymphatics going to the liver. So, it is not improbable, says Nöller, that the forms seen in the liver and spleen were in reality merozoites of the intestinal organism.

In *Fulica atra* [33] we have described a so-called *Toxoplasma* (*T. fulicæ*) which has very curious features : (*a*) firstly, there is no Coccidian parasite in the intestinal tract of this bird, and consequently the hypothesis of Nöller cannot be accepted in this case ; (*b*) secondly, the parasites included in monocytes and multiplying be repeated binary division show tinctorial reactions suggesting a sexuality of the schizonts, a sexuality which seems to continue yet in the products of the division of the schizonts, or merozoites. A similar process of sexuality in agametes was described by Schaudinn in *Cyclospora caryolitica*. Our *T. fulicæ* seems to be a monocytic coccidium, closely allied to the family Cyclosporinæ.

After all these remarks one can see that the bird parasites we are referring to constitute a complex group of organisms which, only provisionally, can be classified as *Toxoplasmata*.

We will now give a list of the Toxoplasms of the Indian birds :—

According to the list of Wenyon.

1. *Pratincola caprata*. *Toxoplasma* (unnamed) Pilmmer, 1916.

To this we will add :—

2. Columba livia (domestic species) *Toxoplasma françæ* Mello, 1935. (Syn. *T. columbæ* Yakimoff and Kohl Yakimoff ?).[34]

* * *

Communicated to the Indian Academy of Sciences

3. *Fulica atra*. *Toxoplasma fulicæ* Mello, 1935.

* * *

Communicated to the XII International Congress of Zoology :—

4. *Butastur teesa*. *Toxoplasma butasturis*, sp. nov, Mello.—Different from the *T. fulicæ* as it has the protoplasm uniformly stained in pale rose and not showing the bitonal coloration suggesting sexuality as referred above. It resembles our *T. françæ* of the pigeon. Very few individuals seen : small parasites as the ring forms of Plasmodids, some larger schizonts with the nucleus more developed, evidence of binary division, often more than one parasite in the same cell.

VI. Microfilarids recorded in Indian Birds.

In this chapter we are obliged to record only our own observations, as we had not at hand the literature dealing with such parasites studied by other authors. Our parasites have

not been named previously when only one sp. of *Microfilarium* has been found in the bird examined from that point of view, as we assume that the parasite will take naturally the specific name related to the host. When, however, more than one species has been recorded, we have given to them specific names. In this list we will characterize and name them according to the principles established above :—

1. *Herodias intermedias* Wagler. *Microfilarium herodiadis* Mello, 1935.[6]

2. *Chloropsis aurifrons davidsoni* S. Baker. *Microfilarium chloropsidis* Mello, 1935.[6]

Communicated to the XII International Congress of Zoology :—

3. *Oriolus xanthornus xanthornus* (L.). *Microfilarium xanthorni*, sp. nov.—Roundish head, posterior extremity thinner, often pointed, often abruptly blunt. Sheath with transverse striation. Nuclear contents beginning at the head with two granules parallel or convergent and continued by nuclei so densely close one to another that it is quite impossible to individualize them as to distinguish the columns. Two spots, one split-like, the other, caudal, oval; however, many specimens where such spots are not visible. Central Viscus seems to be present sometimes. Breadth 5–7 microns. Length measured on 13 specimens : 60, 38, 42, 65, 50, 45, 58, 40, 36, 61, 46, 75, 78 microns (in collaboration with my pupil Xantarama Edó).

4. *Chloropsis jerdoni* Blyth.—Two specimens of this bird examined in collaboration, one with my pupil, V. V. Quenim, the other with my pupil, Narana L. Sansguiri, showed a *Microfilarium* with the following characters : provided with sheath without transverse striation, head roundish, tail pointed, sometimes slightly blunt, conical. Cellular contents disposed in two columns, beginning at 2 to 4 microns from the head where two or three nuclei are very distinct, rod shaped and disposed in an incomplete V. In the majority of specimens this double column may be followed till the central spot, which is very distinct. Cephalic split-like interruption sometimes visible. Central spot at 23–37 microns. Maximum bread 4–7 microns. Length taken on 24 specimens 181, 156, 159, 111, 113, 108, 125, 124, 153, 124, 143, 114, 224, 138, 103, 155, 130, 145, 113, 131, 143, 129, 104, 97 microns. This *Microfilarium* is different from *M. chloropsidis* parasite of *Chloropsis aurifrons davidsoni*, in the absence of the transverse striation of the cuticle which characterizes the last one. We name it *Microfilarium jerdoni*, sp. nov.

5. *Thereiceryx zeylanicus* (Gmelin).—This bird studied in collaboration with my pupil Fernando Lopes harbours in its blood two species of *Microfilaria*.

Type A.—Strongly curved, sometimes with the anterior half taking a spiral disposition. Anterior end round, posterior end pointed and followed by a tail-like flagellum of nearly 30 microns length. Very thin sheath. Nuclear contents beginning at 3·4 microns behind the anterior end in two columns disposed in V or U in their initial portion. One constant caudal spot, oval, at 80–90 microns from the head. Central Viscus not visible. Breadth 3, 5 to 4 microns. Length taken on 10 specimens 185, 186, 220, 191, 191, 205, 225, 205, 184, 184 microns. We have named it *Microfilarium jorgei*, sp. nov., in homage to Prof A. R. Jorge, President XII. Int. Congr. of Zoology.

Type B.—More or less rectilineal, anterior end round, posterior one roundish blunt. Sheath very thin. Two nuclear columns beginning almost immediately behind the head. At nearly 30 microns from the head one longitudinal spot, split-like; central spot oval, at nearly 70–75 microns from the head. Breadth 3-4 microns. Length measured in 14 specimens 110, 97, 97, 92, 97, 106, 96, 100, 104, 100, 112, 103, 104, 91 microns. We name this type *Microfilarium thereicerycis*, sp. nov.

6. *Dissemerus paradiseus malabaricus* (Latham).—Studied in collaboration with my pupil Emerciano Dias. Very abundant infection, showing in every microscopic field 5 to 6 microfilaria. Provided with sheath, anterior end rounded, posterior one pointed but blunt. Nuclear column beginning at 6–7 microns from the head Nuclei disposed in two columns, sometimes three, irregularly interrupted here and there. One constant caudal spot situated at nearly 83–85 microns from the head. More or less irregular interruptions seen on cephalic and central portions. Breadth 5–7 microns. Length: I specimen 142; 5-160; 5–170; 1-175; 2–180; 2-190. We name it *Microfilarium dissemeri*, sp. nov.

7. *Dendrocitta rufa rufa* (Latham).—Studied in collaboration with my pupil Raia Sirvoicar.

8. *Dendrocitta rufa vagabunda* (Latham). Studied in collaboration with my pupil V. Visvonath Quenim.

Both these birds were parasitized by the same species of *Microfilarium* which we name *Microfilarium dendrocittæ*, sp. nov. Straight or slightly curved, anterior end round, posterior end pointed, fusiform. Nuclear contents beginning by two to four nuclei just behind the head and filling completely the body in order that the sheath is hardly visible. The nuclear columns are 2 or 3. One spot, generally circular. nearly at 45 microns from the head. Breadth circa 5 microns. Length measured in 24 specimens 80, 79, 82, 76, 78, 56, 65, 74, 77, 79, 80, 80, 74, 70, 78, 67. 70, 79, 69, 72, 74, 62, 76, 75 microns.

9. *Aegithina tiphia* (L.).—Studied in collaboration with my pupil Raia Sirvoicar. Microfilarium with anterior end blunt, and the posterior one pointed. Nuclear contents beginning at

10–12 microns from the head and filling the whole body. In the anterior part of the sheath, which is devoid of nuclei, some minute granules taking a chromatic stain are often noticed. Median spot either oval or V-shaped, fairly constant. One or two accessory spots on the post part. Central viscus a little behind the median spot. The irregularity of the number and of the situation of these spots characterizes this *Microfilarium*, which we name *M. ægithinæ*, sp. nov. Breadth 5–7 microns. Length 1–85 microns; 2–100; 1–105; 4–125; 1–145; 3–165; 1–175; 4–200; 1–215. Free part of the sheath before the head 3 to 9 microns. Free part of the tail, when present, 12–16 microns.

Two other specimens studied in collaboration with my pupil R. Sirvoicar and Hori Curchorcar showed the same *Microfilarium*.

10. *Centropus s. parroti* Str.—Very scanty infection by a *Microfilarium*, only 4 parasites having been found in 7 slides examined. Provided with sheath, anterior extremity blunt, posterior one pointed, tail-like. Central viscus, very marked, under the form of a large granular band occupying the 2nd fifth of the body. It stains violet with Romanowsky in contrast with the uniform bluish colour of the body where no nuclei are distinctly seen. This constitutes a peculiar characteristic of this *Microfilarium*, whose body does not also show distinct spots. In the middle there is perhaps a slight V-like interruption and at the tail another, very incomplete; but these spots (?) also are not constant. Breadth 6-7 microns. Length 100–150 microns. We name this *Microfilarium centropi*, sp. nov.

11. *Centropus s. parroti* Str.—The *Microfilarium* of this bird is quite different from that described above. Sheath with transverse striation completely filled up with nuclei, which beginning some 10 microns behind the anterior rounded end, run into 3, sometimes 4 compact columns, till the posterior end which is abruptly truncated and has at the end a slight enlargement. In some specimens three distinct spots: one cephalic, not reaching the whole breadth of the parasite, one median of the same type, and one caudal, very large, quadrangular, constituting a complete interruption in the nuclear column. Central Viscus, when present, situated in the anterior third. We have named this *Microfilarium mccanni* sp. nov. in homage to Mr. C. W. McCann, of the Bombay National History Society.

12. *Nycticorax n. nycticorax* (L.).—*Microfilarium* with indistinct sheet. Anterior end blunt, posterior one pointed. Compact nuclear column, filling the whole body of the parasite and beginning shortly behind the anterior end by two nuclear masses disposed as a V. One central spot fairly constant but not reaching the whole breadth of the parasite. Central Viscus, when present, under the form of an oval body, stained blue with Romanowsky and situated a little behind the median spot. Breadth 6–7 microns. Length 60–95 microns.

We name it *Microfilarium nycticoracis*, sp. nov.

13. *Ardeola grayii* Sykes.—*Microfilarium* with a thin sheath provided with transverse striations. Head rounded, posterior end tail-like, abruptly pointed and the nuclear contents at this level contracted in the majority of specimens in the form of the biting sting of a scorpion. The nuclear column very compact, beginning a little behind the head by two distinct cellular groups. One constant central spot circular or V-like. Central Viscus not distinct however in one or two specimens it seemed to be present under the form of a crescent shaped body, located behind the central spot. Two other spots, one central, other caudal, not always constant and irregular either in their form or size, as sometimes the interruption reaches the whole breadth of the nuclear column, and sometimes not. Breadth 6–8 microns. Length ; 2–57 microns ; 4–65, 7-70, 15-75, 3–80, 5-85, 5–90, 5–95, 2–100, 1–104, 1–108, 1–119.

We name it *Microfilarium ardeolæ*, sp. nov.

14. *Streptopelia s. cambayensis* (Gmelin).—*Microfilarium* with a very thin sheet, with transverse striation hardly visible. Anterior end rounded and devoid of nuclei in some 10–12 microns of length but in this space two fine lines can be seen representing the two compact columns of nuclei which fill the whole body of the parasite. Three spots, cephalic, median and caudal, irregular in form and sometimes not complete. Central Viscus sometimes visible behind the median spot. Posterior end pointed but ending abruptly as a truncated cone. Breadth 6-7 microns. Length 160–236 microns.

We name it *Microfilarium streptopeliæ*, sp. nov.

15. *Acridotheres tristis tristis* (L.).—*Microfilarium* with sheath, the nuclear column beginning 5-6 microns behind the anterior end which is enlarged comparatively to the breadth of the body. The nuclear mass does not fill the body completely. The posterior end is either obtusely pointed or abruptly cut off and what is curious is that, despite the slides having been beautifully stained with Romanowsky, no separate nucleus could be seen in the body, the entire contents forming a compact mass, ribbon-like, irregularly twisted, where the spots are scarcely visible (one median, one caudal, not always visible). Central Viscus when present situated behind the median spot. Breadth 4-5 microns. Length 90, 100, 104, 118, 120 microns.

We name it *Microfilarium acridotheris*, sp. nov.

16. *Dicrurus m. macrocercus* Vie.—Very short *Microfilarium*, with roundish head and the posterior end possessing a small protuberance, curved as an appendix and very peculiar as it resembles perfectly the coecal appendix. Central spot oval or band-like ; often a caudal spot. Nuclear column beginning three microns behind the anterior end. Two rows of nuclei. Breadth 5-6 microns. Length 68, 85, 71, 73, 66, 65, 74, 63, 69, 70, 50. 62, 60, 51 microns.

We name it *Microfilarium dicruri*, sp. nov.

17. *Pycnonotus luteolus* (Less.).—Studied in collaboration with my pupil Emerciano Dias. *Microfilarium* which has the peculiarity of not showing any spot at all, the nuclear contents very closely packed up in three columns and beginning quite near the head, one or two nuclei quite distinct and not filling the sheath at this level. Between the nuclei there are frequent small interruptions, not constituting however definite spots. Breadth 5, 5 microns. Length 74, 82, 79, 82, 70 microns.

We name it *Microfilarium pycnonoti*, sp. nov.

18. *Geocichla c. cyanotis* (J. & S.)—Studied in collaboration with my pupil António Reveredo. *Microfilarium* with the anterior end rounded, posterior one pointed, sometimes ending in a very thin point. Nuclear contents beginning at 1–3 microns, from the head, and disposed in 2 or 3 columns, often very closely fused together. One caudal spot, well marked. Some other interruptions, 1 to 3, whose situation varies according to the specimens, but generally in the middle and posterior part. General morphology rectilineal or more or less curved. Breadth 4–6 microns. Length 77, 66, 60, 73, 65, 67, 57, 56, 82, 70, 79 microns.

We name it *Microfilarium geocichlæ*, sp. nov.

19. *Geokichla citrina* (L.).—Studied in collaboration with my pupil Alberto de Mello Furtado, this bird harbours three types of *Microfilaria*.

(*a*) Type I. Perfectly similar to the above described with the only difference that in some specimens three spots (median, posterior and caudal) are often visible.

This parasite is therefore the *Microfilarium geocichlæ* described above.

(*b*) Head irregularly roundish, narrower than that of the type (*a*). Two rod-like nuclei at a short distance from the head. Tail pointed, very narrow, curved. General morphology regularly sinuous. Two nuclear columns. Two spots very distinct. one cephalic, the other caudal.

In some specimens Central Viscus behind the first spot, but not very distinct. The nuclear columns are very close to the sheet which is perfectly visible at the cephalic region. Rare specimens with a third median spot. Breadth 4 microns. Length 93, 106, 95, 123, 114, 102 microns.

We have named this parasite *Microfilarium herculani*, sp. nov. in honour of Prof. Herculano de Sá, of the Seth Gordandas Sunderdas Medical College of Bombay.

(*c*) This is the largest *Microfilarium* hitherto found in our studies. Head large, recurved, with one or two granules. Sheath very large, the nuclear contents in two columns often very closely packed up and forming a narrow, sinuous ribbon, running in the interior of the sheath which is not at all filled by the nuclear contents. Sometimes, due probably to bad stain-

ing, the nuclei are scarcely visible and the whole of the parasite seems uniform with one or more areas irregularly stained. Three spots: cephalic, median, caudal. Tail pointed. Breadth 7-8 microns. Distance from the head to the different spots: to the cephalic circa 40 microns, to the central circa 82, to the caudal circa 131. Length 264, 294, 325, 304, 242, 330 microns.

We have named it *Microfilarium prateri*, sp. nov. in honour of Mr. S. H. Prater, Curator, Bombay National History Society.

20. *Anthus r. rufulus* Vie.—Studied in collaboration with my pupil António Reveredo, this bird harbours three species of *Microfilaria*.

(*a*) Head roundish, posterior end pointed and provided with an appendage similar to the biting nail of a scorpion. Nuclear contents beginning as two nuclei just behind the head, one of them generally very close to the sheath. Two, rarely three columns of large nuclei, filling completely the interior of the sheath, so closely packed up that it is often difficult to distinguish them separately. Median and caudal spots fairly visible. Cephalic spot often present but not so regular. General morphology: straight or more or less sinuous with the tail sometimes curved. Distances from the head to the median and caudal spots generally 47 and 64 microns. Breadth 5·5–6 microns.

Length 74, 80, 78, 76, 73, 70, 69, 61, 65, 75, 79 microns.

We name it *Microfilarium anthi*, sp. nov.

(*b*) Head elliptic, tail blunt, conical. Nuclear contents beginning just behind the head, as two rod-like granules united to the sheath and continuing with two columns of small nuclei very closely packed up and filling completely the interior of the sheath. Two spots: one cephalic, split-like, the other caudal. General morphology more or less rectilineal or gently curved. Average distance from the head to the cephalic split-like spot 32 microns; to the caudal spot 74 microns. Breadth 3·5–4 microns. Length 111, 108, 109, 112, 94, 107, 95, 95, 97, 99, 110, 125 microns.

We have named *Microfilarium prashadi*, sp. nov. in honour of Dr. Baini Prashad of the Indian Museum, Calcutta.

(*c*) Curved, sinuous or S-like. Roundish head where the two nuclear dots make a kind of hernia not allowing clearly to individualize at this level the outline of the sheath. Posterior extremity fusiform, but somewhat blunt. Nuclear contents disposed in two, rarely three columns often fused together in one single rank very close to the sheath. Spots often not visible, sometimes one median and one caudal, not attaining the whole nuclear column. Breadth 3·5 microns. Length 52, 58, 57, 54, 53, 45, 56, 55, 32, 46, 50, 48, 45 microns.

We have named it *Microfilarium horai*, sp. nov. in honour of Dr. S. L. Hora of the Indian Museum, Calcutta.

21. *Saxicoloides fulicata* (L.).—Studied, in collaboration

with my pupil Quensova M. Bandari, this bird showed a large *Microfilarium* provided with a sheath and having the head roundish, the tail pointed, the nuclear contents in three columns just behind the head and ending in the tail in a thin nuclear mass with constant transverse interruptions. Three spots, cephalic, median and caudal, not reaching the whole mass of the nuclear contents. Another very interesting fact is that the nuclear contents are often contracted in a thin ribbon-like band, leaving between it and the walls of the sheath a large free space. Rectilineal or more or less sinuous. Cephalic spot at 33 to 52 microns from the head. Breadth 9 microns. Length 180, 117, 140, 125, 208, 231, 146, 235, 211, 132, 150, 162 microns.

We name it *Microfilarium saxicoloidis*, sp. nov.

22. *Copsychus saularis* (L.).—In collaboration with my pupil Fernando Lopes I found in this bird a more or less sinuous *Microfilarium*, with roundish head where two granules mark the beginning of the nuclear mass; posterior extremity having a caudal, very effilated appendix, of some 32 microns in average. Two nuclear columns. Three spots, often not very distinct, situated at *circa* 47, 89, 110 microns from the head. Breadth 3–4 microns. Length 177, 163, 211, 168, 194 microns. Length of the tail 31, 30, 28, 30, 35, 37 microns.

This *Microfilarium*, which was also found in another specimen studied in collaboration with my pupil Alberto P. L. Affonso has been named by us *Microfilarium moruoni*. sp. nov.

Second type.—In the specimen, studied together with my pupil A. P. L. Affonso, we have found another type of *Microfilarium* with the following characters. Sheath prolonged beyond the caudal pole of the nuclear mass, forming an appendage of nearly 30 microns and having the appearance of a glove finger. This constitutes the principal characteristic of this parasite. Nuclear mass beginning by two granules and not filling the whole breadth of the parasite, so that there is a large space between the nuclear mass and the wall of the sheath. Nuclear columns two, nuclei very closely packed up. In well developed specimens two split-like spots, cephalic and caudal and one median oval spot not reaching the whole mass of nuclei. The cephalic pole may also show sometimes a small sheath appendage where some granules and fibrils, lightly stained, are visible, in contrast to the quite clear zone of the caudal appendage. Breadth 5 microns. Length 139, 130, 86, 103, 125, 151, 160, 177 microns. Caudal glove finger appendage 18 to 45 microns. Cephalic appendage 4 to 20 microns.

We have named it *Microfilarium copsiyci*, sp. nov.

23. *Lalage melaschista* (Hodg.).—Studied in collaboration with my pupil Fernando Lopes. *Microfilarium* having a roundish head with two granules often united under the form of an U. Posterior extremity often pointed in a short point, often blunt. Nuclear contents in two columns (often three distinctly visible at

the anterior extremity). One constant split-like spot at 36 to 60 microns from the head, according to the specimens. Cephalic spot, when visible, at 20–25 microns from the head. Caudal spot rarely seen. Some specimens with the Central Viscus of Manson situated rather on the posterior part at some 55–60 microns from the head, Breadth 4–5 microns. Length 69, 82, 85, 57, 72, 103, 96, 98, 110 microns.

N.B.—Three specimens were found with the posterior extremity as rounded as the head. One of these specimens showed only one spot at 62 microns: the other two 2 spots. Length 79, 62, 50 microns. As the posterior extremity of the *Microfilarium* shows a great polymorphism, we believe that these three forms are only morphological variations of the same species which we name *Microfilarium lalagei*, sp. nov.

* * *

Microfilarids found during our actual researches.

(See Plates 2 and 3.)

24. *Molpastes cafer* (L.).—Studied in collaboration with my pupil Narcinva V. S. Velingcar.

Small and large *Microfilarium* with sheath and nuclear contents in two columns well marked on the head which is roundish. They are afterwards very closely packed up and interrupted by three spots: one cephalic, one caudal, both not reaching the whole mass of the nuclear contents and one median. split like, complete, and more constant than the former. Posterior extremity pointed, often very narrow. Breadth 7-8 microns. Length 50–60 microns.

We name it *Microfilarium molpastis*, sp. nov.

25. *Turdus merula nigropileus* Laf.—Shot at Nagoa (Salcete) and identified by Mr. S. H. Prater. Studied in collaboration with my pupil Miss Ciriaca Vales. *Microfilarium* with rounded head and blunt tail. Nuclear contents beginning at 3 to 4 microns from the head and disposed in two, sometimes three columns, often in V on the initial portion. Number and form of the spots variable: in general there are three spots, one cephalic, one median, one caudal, often oval, often split like. Central Viscus when present, in front of the median spot. Maximum breadth 3–6 microns. General form rectilineal, rarely sinuous. Length 1 110 microns; 3–115; 2–120; 2–130; 1–140; 3–145; 1–150; 1- 160; 1–170; 2–180; 3–190; 2–200.

We name this *Microfilarium merulæ*, sp. nov.

26. *Monticola solitaria pandoo* Sykes, (studied in collaboration with my pupil Narcinva V. S. Velingcar).

The Microfilarium of this bird shows the peculiarity of possessing a varied number of spots. Sheath without transversal striation. Nuclear contents in two distinct columns, beginning shortly behind the anterior end which is roundish. Posterior end pointed, more or less blunt sometimes, and con-

stituting a short tail. Cephalic spot, often split like, central spot, generally oval, both these spots being constant. We have found 3 specimens with 5 spots, 2 with 4 spots. Breadth *circa* 7 microns. Length 98, 122, 155, 170, 142, 181, 163, 169, 181, 199 microns.

We name it *Microfilarium monticolæ*, sp. nov.

* * *

VII.

During this work many birds did not show any parasites at all. This does not mean, indeed, that they are free of blood parasites : many specimens were negative, whilst others, belonging to the same species were infected.

The negative birds are here recorded merely to show the work accomplished for this paper which, to a certain extent, gives a contribution too for the study of ornithological fauna in Portuguese India.

Indian birds which did not show any blood parasite at all.

(1) *Demiegretta asha* (Sykes).
(2) *Numenius p. phæopus* (Linn).
(3) *Tringa hypoleucos* Linn.
(4) *Larus genei* Breme.
(5) *Egretta alba alba* (Linn).
(6) *Phœniconaias minor* Geoff.
(7) *Nettion crecca crecca* (Linn).
(8) *Spatula clypeata* (Linn).
(9) *Leucopolius a. alexandrinus* (Linn).
(10) *Elathea jocosa* Gestel.
(11) *Tchitrea paradisi paradisi* (Linn).
(12) *Graucalus m. macei* Less.
(13) *Eremopterix grisea* Kaup.
(14) *Xantholæma haemacephala lutea* (Lesson).
(15) *Merops o. orientalis* Latham.
(16) *Erolia m. minuta* (Leisler).
(17) *Chaptia ænea malayensis* A. Hay.
(18) *Merops superciliosus javanicus* Horsfield.
(19) *Streptopelia chinensis suratensis* (Gmelin).
(20) *Tringa glareola* Linn.
(21) *Saxicoloides fulicata cambaiensis* Latham.
(22) *Pellorneum ruficeps* Swainson.
(23) *Merops superciliosus* Linn.
(24) *Chaptia ænea* (Vieillot).
(25) *Haliastur indus* (Bodd.).
(26) *Alcedo atthis* (Linn).
(27) *Chrysocolaptes guttacristatus* (Tickell).

(28) *Dicrurus cœrulescens* (Linn).
(29) *Cryptoplectron erythrorhychum* (Sykes).
(30) *Irena puella* (Lath).
(31) *Dendrophasa bicincta* (Jerdon).
(32) *Pericrocotus speciosus* (Latham).
(33) *Dicœum minullum* Swinhoe.
(34) *Xantholœma malabarica* (Blyth).
(35) *Æthiopsar fuscus* (Wagler).
(36) *Hypothymis azurea sykesi* (Baker).

All these birds were identified by Mr. Prater or Mr. McCann, of the Bombay National History Society, to whom my best thanks are here expressed.

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ARTICLE NO. 4.

The clitellum and sexual maturity in the Megascolecinæ.

By G. E. GATES *and* MAUNG HLA KYAW.

In the Oligochæta specific characterization rests largely on the sexual organs. If these organs are not fully developed in the systematist's specimens, inadequate or even erroneous specific diagnoses may result. The clitellum which is present in sexually mature individuals has therefore been regarded as of considerable importance to the taxonomist as an indication of the sexual maturity of his material.

In earthworms of the subfamily Megascolecinæ, presence of spermatozoa in the seminal chamber of a spermathecal diverticulum is indicated by an iridescence that is visible through the thin wall of the chamber. Spermathecal spermatozoa are always received (so far as is known) from another worm during the course of a copulatory act. The iridescence is, accordingly, evidence that copulation has taken place. But, iridescent seminal chambers are occasionally found in aclitellate individuals. In these worms the sexual organs are mature and we have, apparently, mature though aclitellate specimens. Such worms either copulated in an aclitellate condition (the clitellar glandularity still undeveloped when the worms were killed) or else the worms copulated in a clitellate condition, after which the clitellum disappeared.

In an attempt to discover if the second alternative is a correct explanation, observations have been made on several Rangoon species of Megascolecinæ in which clitellar regression takes place under laboratory conditions. Hitherto only one species, *Pheretima posthuma* (L. Vaillant) 1868, has provided any evidence of especial interest.

A number of clitellate specimens of *P. posthuma* were collected in the neighbourhood of the University on the fifteenth of August. Of these worms 28 were killed and preserved by the usual technique while the remainder were placed in large, earth-filled pots, one worm in each pot. A fortnight later the clitellar region of the worms in the pots was much less distinct and on the clitellar segments setæ were readily recognizable without a lens. Four and five weeks after the beginning of the experiment the worms were killed and preserved by the usual methods.

No clitellar glandularity is recognizable on the experimental worms. Intersegmental furrows 14/15 and 15/16 are visible, dorsal pores on the clitellar furrows are either present or represented by pore-like, possible non-functional markings. Setæ are present ventrally and laterally but are lacking dorsally. The

female pore cannot be identified though its site is marked by a tiny, transversely placed depression. Colouration of the clitellar segments is slightly different from that of the neighbouring segments and this colouration together with the absence of setæ dorsally distinguishes the post-sexual condition of segments xiv to xvi from the juvenile or pre-sexual condition.

Of the 28 worms killed at the beginning of the experiment each specimen is characterized by an iridescence of every seminal chamber. In view of this uniformity it seems fair to assume that all of the experimental worms had copulated prior to capture. In one of the experimental animals each seminal chamber is characterized by a spermatozoal iridescence. In two other worms each seminal chamber is filled with an opaque, whitish material with no iridescence. In another specimen the seminal chambers are translucent. In the last worm, which was killed several days later than those just mentioned, the seminal chambers are all transparent.

Thus, in at least one species of the Megascolecinæ, spermatozoa can be retained within the seminal chambers unmodified or sufficiently unmodified to produce the iridescence until after the clitellar glandularity has disappeared.

The non-iridescent opacity, translucence and transparency of the contents of the seminal chambers are indications of changes presumably of a digestive and absorptive nature taking place within the chamber. The chamber does not appear to undergo any noteworthy change in size and shape during the process of spermatozoal digestion.

Published accounts of copulation tend to indicate that only clitellate individuals actually participate in the sexual act, and further evidence for such a belief is afforded by the observations on *Pheretima posthuma* just mentioned. But copulation has been studied in only a few species and in only one Megascolecine form (a species of *Pheretima*). It would be premature, therefore, to deny that aclitellate individuals can copulate, especially since the primary function of the clitellum seems to be the formation of cocoons, a post-copulatory act.

In contrast to the condition just discussed, in certain species of *Pheretima*, clitellate specimens have occasionally been found in which the testes are undischarged or juvenile while the seminal vesicles are rudimentary, juvenile or entirely lacking. In this case there is no possibility of a post-sexual regression of the sexual organs and we have fully clitellate but sexually immature specimens (at least so far as the male organs are concerned). Such specimens usually are heavily infested with gregarines or show evidence of having been so infected. (*Note.*—The parasites are not in, or even near, the organs affected.) In spite of the heavy infestation the hosts are of normal size or may even be unusually large and apparently, at least so far as external appearances are concerned, quite healthy. In these worms the

parasites appear to have been responsible for the inhibition or restriction of development of the sex organs without affecting the development of the clitellum.

Avel (*C.R. Soc. Biol. Paris*, Vol. 96, 1927 and *C.R. Ac. Sci. Paris*, Vol. 186, 1928) has shown that the clitellum in certain species of Lumbricidæ can develop in the absence of the gonads, both testes and ovaries. Avel concludes (according to Stephenson, 1930, p. 404) that the appearance of the clitellum as a secondary sexual character is dependent on a particular condition of the body fluids. If the parasites in the genus *Pheretima* can affect the host through the body fluids in such a way as to inhibit development of certain sex organs, at the same time permitting the development of others, and in particular the clitellum, a similar interference with the developmental processes should be possible experimentally.

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Article No. 5.

The Alimentary Canal of *Epilachna indica* (Coccinellidæ : Coleoptera) with a discussion on the activity of the mid-gut epithelium.

By S. Pradhan.

Contents.

1. Introduction.

The investigation of alimentary canal of *Epilachna indica* was taken up in connection with a more comprehensive work on a comparative study of the alimentary canals of carnivorous and herbivorous beetles of the family Coccinellidæ (Coleoptera), but as the study of *E. indica* revealed a large number of both structural and physiological peculiarities which are important from the view-point of digestion among insects in general, I am publishing this account separately. The alimentary canal of another species of *Epilachna*, i.e. *E. corrupta* has already been described by two American workers, Potts (1927) and Burgess (1932) ; but unfortunately the accounts of these two investigators differ from each other, and my own findings on *E. indica* differ in important respects from those of both of these authors on *E. corrupta* ; I am therefore presenting my results in an extended form.

2. The course of the alimentary canal.

The alimentary canal of *E. indica* (fig. 1) is a convoluted tube about three times the length of the body of the insect.[1]

[1] As the insect shows sexual dimorphism in its size, the length of the gut also varies in the two sexes, being 3 cm. in the case of the female and only 2·75 cm. on the average in the male. However, the ratio between the length of the insect and that of its alimentary canal in the two sexes remains almost the same.

Like the typical gut of an insect, it consists of three main divisions—the fore-gut, the mid-gut, and the hind-gut of which the second division is the longest in this species. The gut

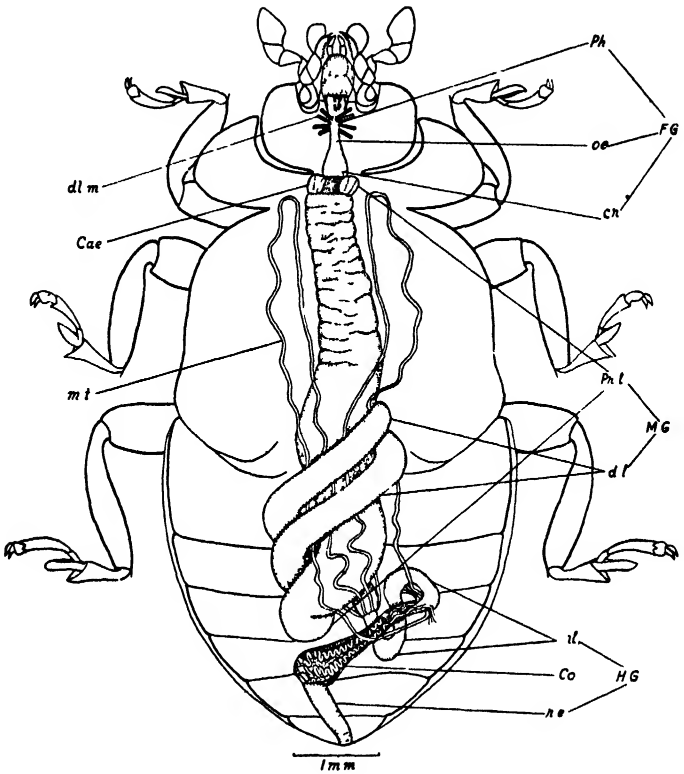

FIG. 1.—The alimentary canal of *E. indica* in situ: the coils have been slightly opened to render the coiling clear: *cæ*, glandular diverticula; *co.*, colon; *cr.*, crop; *d.l.*, distal loop; *dl.m.*, dilator muscles; F.G., fore-gut; H.G., hind-gut; *il.*, ileum; M.G., mid-gut; *m.t.*, malpighian tubules; *œ.*, œsophagus; *ph.*, pharynx; *pr.l.*, proximal lobe; *re.*, rectum.

generally and the mid-gut specially are capable of distention and contraction within a fairly wide range. The diameter of the alimentary canal at different levels depends largely on two factors: firstly, on the presence or absence of food in that region, and, secondly, on the phase of the peristaltic wave at which that part of the gut has been fixed. The peristalsis of the gut takes the form of a series of discontinuous waves which pass along the gut changing the diameter of any portion, specially that of the mid-gut. These peristaltic movements can be observed under

a binocular microscope when a freshly narcotized insect is dissected in normal saline solution.

The fore-gut.—The fore-gut is a comparatively short flask-shaped tube, almost wholly confined to the head-capsule. It consists of: (1) the *buccal cavity*, (2) the *pharynx*, (3) the *œsophagus*, (4) the *crop*, and (5) the *œsophageal valve*, the last being telescoped within the anterior end of the mid-gut. The mouth leads through the buccal cavity into the pharynx but there is hardly anything to distinguish the boundary of the buccal cavity from that of the pharynx, the one passing insensibly into the other.

The *pharynx* is a short tube which shows a slight enlargement and then narrows evenly behind to form what may be called the pharyngeal 'constriction'. A number of stout dilator muscles arranged in small groups (*dl.m.*) arise from the wall of the buccal cavity and the pharynx. These muscles run in different directions and are inserted in the different parts of the head-capsule and the tentorium. From their position and attachment, there seems little doubt that they serve to dilate the buccal and the pharyngeal cavities.

Behind the pharyngeal constriction lies the short narrow *œsophagus* which widens posteriorly to form the *crop* (*cr.*). At its posterior end the crop narrows down and becomes telescoped into the anterior end of the mid-gut, forming what is commonly known as the '*œsophageal valve*' (fig. 6).

The mid-gut.—The mid-gut forms the most prominent region of the alimentary canal and is variously coiled and twisted, lying along the median axis of the thorax and abdomen as shown in fig. 1. In a dissection it appears to consist of two distinct divisions: (1) an almost straight *proximal lobe* (*pr.l.*) and (2) a coiled *distal loop* (*d.l.*). From the junction of the head with the thorax the proximal lobe runs behind almost in a straight line, lying just beneath the heart and extending up to the third visible sternite of the abdomen. The anterior end of the proximal lobe is produced dorso-laterally into a pair of inconspicuous but distinct pocket-like glandular diverticula,[1] each of which is divided externally by two or three longitudinal grooves. Behind these diverticula, the wall of the proximal lobe shows a large number of both transverse and oblique folds. The extent of these folds in this region shows a great variation in different specimens, depending apparently on the course of peristalsis. It may be noted, however, that the longitudinal muscles (*vide infra*) are not included within these folds, since in a dissection of a fixed specimen, they can be clearly seen stretching across the grooves between these folds.

[1] These diverticula have not been described in *E. corrupta* either by Potts or by Burgess.

At its hind end, the proximal lobe becomes narrow and is sharply bent downwards and then outwards, emerging out on the left side of the proximal lobe and forming the *first limb* of the distal loop. This limb now coils round the proximal lobe, and on reaching a little to the left of the mid-ventral line, runs back as the *second limb* lying parallel and anterior to the first limb. It now crosses the first limb and the proximal lobe and reaches the level of the hind end of the latter. Here the mid-gut passes into the hind-gut, the junction of the two being marked by the origin of six malpighian tubules. The distal loop has a narrow calibre and does not show any regular folds like those present on the proximal lobe, though a few folds may be present in some parts of the distal loop as well.

The hind-gut.—The hind-gut is a much shorter tube than the mid-gut, though it is more than three times the length of the fore-gut. It consists of: (1) the *ileum*, (2) the *colon*, and (3) the *rectum*. Just behind the origin of the malpighian tubules the *ileum* forms two short loops, and then gradually widens out to form the pear-shaped *colon* (*co.*). Both the colon and the hinder part of the ileum have malpighian tubules adhering to their walls. Posteriorly the colon ends rather abruptly and is clearly demarcated from the highly muscular rectum (*re.*). The rectum is a short tube and looks like an elongated sphincter on account of its thick musculature.

When the coils of the alimentary canal are undisturbed, the two limbs of the distal loop, the distal portion of the proximal lobe and the distal part of the ileum together with the colon form four parallel coils as shown in fig. 1. All these structures look quite plump and fresh even in a fixed specimen.

3. Histology of the alimentary canal.

Essentially the structure of the alimentary canal of *E. indica* is not at all different from that of any other typical insect. It consists as usual of a single layer of internal epithelial cells surrounded first by an inconstantly distinguishable basement membrane and then by the layers of circular and longitudinal muscles. The wall of the gut is also lined internally with a variable intima which is chitinous in the fore- and the hind-guts. Externally the gut is surrounded by an inconstantly noticeable fascia.

The histology of the alimentary canal presents difficulties which seem insurmountable on a first examination of the serial sections. These difficulties are due to the fact that the histological characters of the different regions of the alimentary canal change so rapidly that not only do the cells appear different after every few sections in the series, but that even in the same transverse section, one often finds a large variety not only of the form and size of the cells, but even in the consistency and the

staining capacities of their contents. As a matter of fact, the variations exhibited by the cells of the alimentary canal are so many and so sudden that it is very difficult to co-relate them without constantly taking into consideration the probable physiological phase of these cells.

The fore-gut.—Unlike the condition in *E. corrupta* (Potts, 1927 and Burgess, 1932), the histological character of the fore-gut (figs. 2, 3, 4, 5) in *E. indica* varies considerably in its different regions. The variations relate, firstly, to the foldings of the chitinous intima and secondly, to the relative disposition of the musculature, the character of the epithelium remaining almost constant throughout the length of the fore-gut. The epithelium consists of small cubical cells arranged in a squamous manner within the chitinous intima. The cytoplasm of the cells is very finely granular and the nuclei very well-defined, each nucleus containing generally a single deeply staining granule, the nucleolus. The cell outlines are often indistinct and the basement membrane is hardly distinguishable.

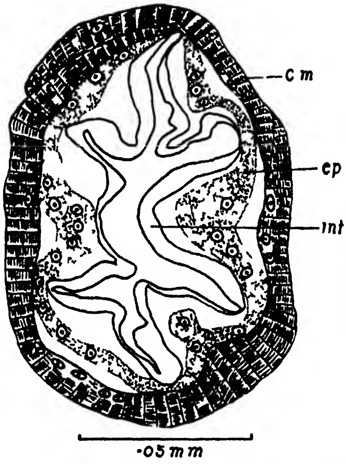

FIG. 2.—T.S. through the pharynx: *c.m.*, circular muscles; *ep.*, epithelium; *int.*, intima.

In sections through the pharynx (fig. 2), the chitinous intima is seen to be strongly developed and may be as much as 8 microns in thickness. It forms a compact layer which stains deep green with indigo-carmine; with eosin it either retains its natural brown colour or only takes up the red tinge of eosin. It is thrown into six longitudinal folds which generally carry the epithelium with them. The outlines of these folds in transverse sections are irregular and inconstant, showing that the height of each fold varies along its length. The musculature consists

almost entirely of moderately developed circular muscles, as hardly any longitudinal strands are visible. Besides, there are radially directed dilator muscles which appear to originate directly from the intima (fig. 3).

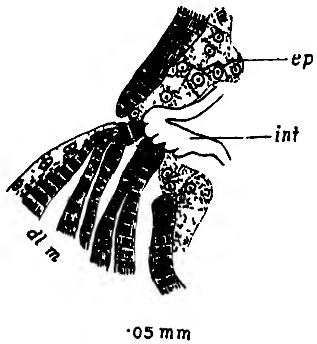

FIG. 3.—A portion of T.S. through the pharynx showing the origin of the dilator muscles: *dl.m.*, dilator muscles, *ep.*, epithelium; *int.*, intima.

In the region of the œsophagus (fig. 4), however, the chitin becomes weaker and less compact, as is shown by the fact that it stains faintly with eosin and indigo-carmine. The intima in this region is extremely thin being only about 2·0 microns thick. The six folds of the wall of the pharynx flatten out and give place to an uneven surface. The circular muscles, like those of the pharynx, are moderately well-developed but in addition, the longitudinal muscles also begin to appear, although they

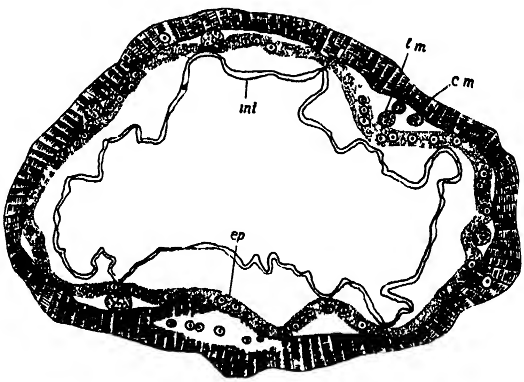

FIG. 4.—T.S. through the œsophagus: *c.m.*, circular muscles; *ep*, epithelium; *int.*, intima; *l.m.*, longitudinal muscles.

consist of only a few very narrow strands lying scattered in the different parts of the œsophagus.

The histology of the pharynx and the œsophagus of *E. corrupta* as described by Potts (1927) seems to be very different from that in *E. indica*. According to him the 'epithelium' of the pharynx in *E. corrupta* 'is not thrown into folds' while the 'intima' and also the epithelium (as shown in his diagram) 'of the œsophagus seem to be thrown into a series of longitudinal folds usually four in number'. Burgess (1932) while describing the same species neither contradicts Potts nor does he make any mention of the longitudinal folds in the œsophagus. In *E. indica* on the other hand, it is the pharyngeal wall that is thrown into six longitudinal folds, there being no longitudinal folds in the œsophageal wall in front of the crop. Potts has also described the presence of teeth on the œsophageal wall but Burgess entirely contradicts this statement. In *E. indica* also, I have not found any teeth at all.

In the region of the crop (fig. 5) the arrangement of the several components of the gut-wall becomes entirely different. The chitinous intima is compact and stains deeply as in the case of the pharynx; and there are four well-defined major longitudinal folds alternating with four minor ones. From each of the major folds arise a number of long narrow bristles which are

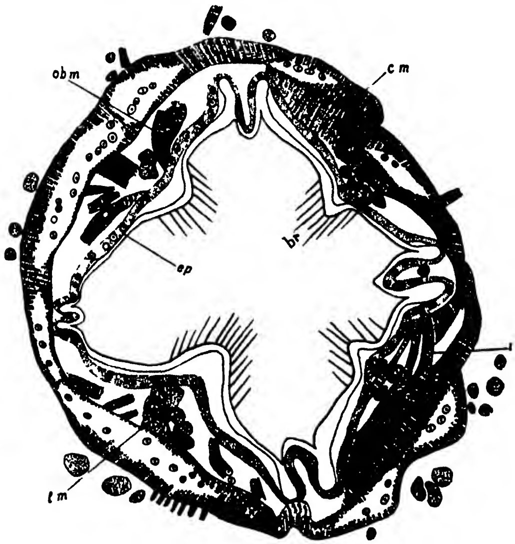

FIG. 5.—T.S. through the crop: *c.m.*, circular muscles; *ep.*, epithelium; *in.m.*, intrinsic muscles; *int.*, intima; *l.m.*, longitudinal muscles; *ob.m.*, oblique muscles; *br.*, bristles.

apparently outgrowths of the chitinous intima. As is clear from fig. 5, the whole wall of the œsophagus is divided by the major folds into four distinct quadrants.

The musculature of the crop is very elaborate and interesting and we can distinguish the following sets of muscles :

1. *Circular muscles.*—These muscles (*c.m.*) are quite thick and surround the gut either completely or partially. The complete muscles are like ordinary circular muscles which surround the crop in a typical insect without showing any connection with the epithelium. The partially surrounding muscles lie among the ordinary circular ones, but have one or both of their ends attached to the epithelium of a fold. This latter type of muscles has not been described in *E. corrupta* by either of the two workers referred to above, and even in other species has been described only in a few cases. Anyhow, the statement generally made that the circular muscles simply encircle the gut without being attached anywhere does not seem to be universally true.

2. *Longitudinal muscles.*—These muscles (*l.m.*) are not so stout as the circular ones. They originate from the epithelium at the posterior free end of the œsophageal valve (*vide infra*) and always lie inside the circular muscles. They run forwards as a few narrow strands in the wall of the œsophagus (already described).

3. *Oblique muscles continuous with those of the mid-gut.*—These muscles (*ob.m.*, figs. 5 and 6) are also fairly stout. Originating at different levels from the epithelium of the major folds of the crop, they run obliquely outwards and backwards and pierce the rest of the musculature and then converge into small groups which run externally to the circular muscles for a short distance, bridge over the œsophageal valve and become continuous with the external longitudinal muscles of the mid-gut. In serial transverse sections, these muscles are cut in different directions. At places they are cut longitudinally and appear to radiate from the epithelium of the major folds ; at other places they are cut transversely and lie outside the circular muscles of the crop. From their mode of attachment it appears that these muscles may be acting as dilators for the major folds, but from the fact that these muscles run outwards and *backwards* it seems more probable, however, that they act as erectors for the bristles which ordinarily remain directed backwards. It may also be noted that these muscles are not the continuations of the longitudinal muscles of the fore-gut. Thus the longitudinal muscles of the fore- and the mid-guts are not continuous as has been generally described in the gut of other insects.

4. *Intrinsic muscles of the folds.*—Besides the circular muscles already described, there are also well-developed circular intrinsic muscles (*in.m.*) in each of the four quadrants of the wall of the crop. These muscles stretch across the two adjacent walls of each fold. The position and attachment of these

intrinsic muscles are evidently related to the formation of these folds. When these muscles contract, the folds project deeply into the lumen of the crop while on their relaxation the folds flatten out.

The musculature of the crop, like that of the whole of the fore-gut, shows an abnormally large number of nuclei (figs. 4 and 5) which are at times arranged in long rows in a manner more or less similar to what has been sketched by Pavlovsky and Zarin (1922) in the case of the stomach of the honey-bee.

After understanding the elaborate structure of the crop, its functions also become sufficiently intelligible. The presence of the strongly developed folds of the intima often reaching quite deep into the lumen of the crop, the long fine bristles which are probably moved by the oblique muscles, and, lastly, the elaborate musculature of the crop as a whole rendering all kinds of movements possible for the wall of the crop—all these lead to the conclusion that the crop is a good churning apparatus for the food. It may also be added that some of my sections show the presence of the mid-gut secretions in the crop, thus indicating that the food and the secretions are mixed up in this part of the gut. Besides the mixing and the churning of food and secretions, it is also possible that when the major folds project into the lumen and their bristles are erected, the bristles may form a good straining sieve.

Such an elaborate structure of the crop has not been described in *E. corrupta*. Potts does not describe any structure and simply writes, 'The crop is not so well developed in *E. corrupta*'. Burgess on the other hand, describes the crop and sketches a section through the same. His sketch and description are surprisingly different from those of mine and the differences become all the more remarkable when we take into consideration the fact that the two are the species of the same genus and possess almost similar habits. In *E. corrupta* there are no definite folds of the intima as in *E. indica*. The spines in *E. indica* are confined to the top of the major folds, while in *E. corrupta* they cover the entire lining of the crop. The musculature of the crop in *E. corrupta* is quite typical while it is much more complex in *E. indica*. The abnormally large number of nuclei in the muscles described above in *E. indica* has neither been described nor sketched in *E. corrupta*. Further in *E. corrupta* Burgess writes that the spines 'are probably to grind up the food', but in *E. indica* the spines are too fine and elongate for grinding purposes ; here they may be acting as a strainer, or helping in the admixture of food and secretions or they may be performing both the functions.

The œsophageal valve.—The so-called œsophageal valve (fig. 6) is a more or less funnel-shaped structure formed by the telescoping of the fore-gut into the mid-gut. It is therefore double-walled, the inner wall being formed of flat fore-gut epithelium lined internally with a chitinous intima which is thrown into four

longitudinal folds as in the crop. The outer wall on the other hand, is formed of very narrow elongate cells with no lining of

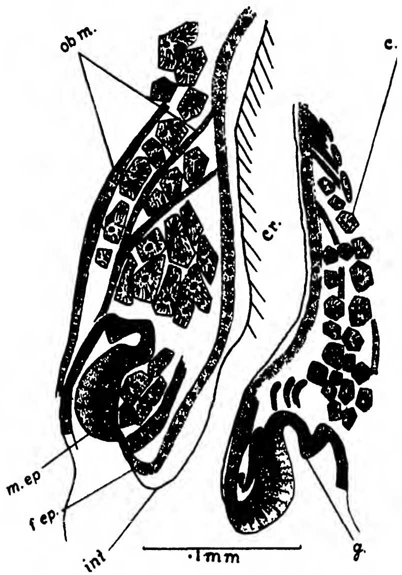

FIG. 6.—L.S. (vertical) through the œsophageal valve: *c.m.*, circular muscles; *cr.*, crop; *f.ep.*, fore-gut epithelium; *int.*, intima; *l.m.*, longitudinal muscles; *m.ep.*, mid-gut epithelium; *ob.m.*, oblique muscles.

the chitinous intima. As a matter of fact, the chitinous intima of the inner wall gradually becomes thinner and thinner till it disappears at the posterior free end of the valve. The change in the shape of the epithelial cells as well as the absence of the chitinous intima indicate that the point of division between the fore-gut and the mid-gut lies at the posterior free end of the œsophageal valve.

The space between the inner and outer epithelia of the valve is filled with longitudinal and circular muscles, the former lying internally to the latter. The circular muscles both within and in front of the valve are much better developed than the longitudinal. In fact, the circular muscles form a regular sphincter in front of the valve, the sphincter being up to 50 microns in thickness.

Mention may also be made here of the slightly raised girdle (*g.*, fig. 6) of the mid-gut epithelium situated just round the base of the œsophageal valve. Wigglesworth (1930) has described similar girdles in several insects including *Coccinella septempunctata*. It is, however, noteworthy that no such

structure has been described in *E. corrupta.* Wigglesworth has shown beyond doubt that these girdles secrete the peritrophic membrane in the insects he has studied, and there is every probability that in *E. indica* as well this girdle performs the same function, although I have not seen a direct connection between the peritrophic membrane and this girdle with much certainty.

The mid-gut.—Histologically the mid-gut (figs. 7 to 13) is distinguished from the fore-gut, firstly, by the absence of the chitinous intima and secondly, by a reversal in position of the two kinds of muscle, the circular ones lying within the longitudinal and not *vice-versa* as in the case of the fore-gut. The two divisions of the mid-gut, i.e. the 'proximal lobe' and the 'distal loop', differ markedly in histological characters and are therefore treated separately.

The proximal lobe.—The anterior part of the proximal lobe extending up to one-third or even one-half of its length appears to be the seat of most vigorous physiological activity. In this portion, the epithelial lining together with its basement membrane and the circular muscles, is almost always found to be thrown into irregular folds, in the formation of which the longitudinal muscles take no part

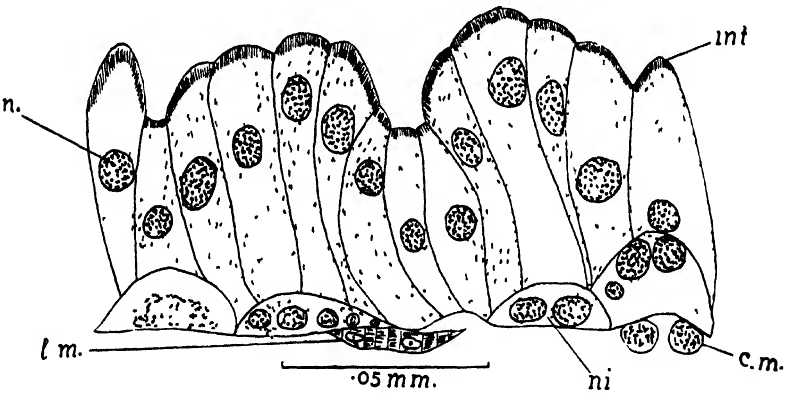

FIG. 7.—Portion of epithelium (L.S.) from the anterior region of the proximal lobe: *c.m.*, circular muscles; *int.*, intima; *l.m.*, longitudinal muscles; *n.*, nuclei; *ni.*, nidi

The epithelium in this region consists mainly of large columnar cells (figs. 7 and 8) with patches of very small cubical cells in between. In the resting stage; the columnar cells are fairly regular in shape but during their physiological activity present a large variety of forms. The cytoplasm is usually granular but its consistency changes largely with its activity. In the resting stage, the inner border of the cells shows a definite and often more deeply staining striated intima, but in the

secreting cells the free margin is often jagged and irregular. The nuclei show a fairly wide range of variation both in their size and in their position within the cell; at some places they lie in a definite wavy line (fig. 7) forming alternate crests and troughs while at other places (figs. 13 and 14) no definite arrangement can be made out. The number of the nuclei within a single cell also varies from zero to several, specially in the actively secreting cells. The outlines of these nuclei are often definite and clear; they are rounded, oval, or even elongate in shape. Internally they are made up of a rather loose network of fine fibrils studded with chromatin granules of various sizes.

At the bases of these columnar cells lie little dome-like structures called the nidi. (*ni.*). These are small multinucleate masses of cytoplasm, over which the columnar epithelium forms a series of arches; at some places the nidi appear to be mere groups of nuclei containing very little or no cytoplasm at all, while at other places they may be represented only by masses of cytoplasm with some chromatin granules scattered therein. From an examination of a large number of nidi, it appears that the amount of cytoplasm bears an inverse ratio to the size and number of the nuclei in the nidus. The nature of these nuclei seems to be the same as that of the nuclei of the columnar cells and their number in each nidus varies from zero to several. The distribution of the nidi is quite irregular; at some places they are so numerous that they lie contiguous to one another, while at other places, they are very sparse. The size and shape of the nidi are also subject to considerable variation; at some places the nidus presents the appearance of a small inverted saucer (fig. 7), while at other places it forms a high dome-like structure (fig. 14*a*).

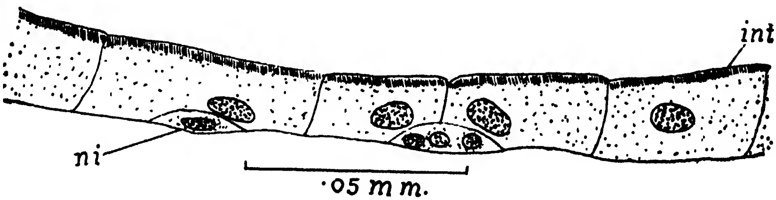

FIG. 8.—Portion of epithelium (T.S.) from the posterior region of the proximal lobe: lettering as in Fig. 7.

In the posterior portion of the proximal lobe (fig. 8) the nature of the epithelium is completely changed. The tall columnar cells of the anterior portion here give place to short flat cells lengthened in the tangential direction; the nidi are very small and scarce and the musculature is distinctly ill-developed.

From the histological characters of the epithelium of the two regions of the proximal lobe, it appears that while copious secretions are poured on the food in the anterior region, the posterior region forms a chamber where these secretions have time to act on the food. The lumen of the anterior region is generally filled with secretions and portions of secretory cells; the lumen of the posterior portion, on the other hand, generally contains a food-cylinder enclosed within a very thin peritrophic membrane. The space round the food-cylinder contains disintegrated cell-products or sometimes even non-disintegrated portions of the epithelium. Even within the food-cylinder one sometimes finds nucleated masses of cytoplasm.

The distal loop.—The most easily noticeable peculiarity of this region (figs. 9, 10, 11, 12) is the irregularity in the height of the epithelial cells. In certain areas, most of the epithelial cells are considerably tall while in others the cells are short and cubical. The transition from tall to short cells is gradual at some places and abrupt at others. The distribution of the nidi is also not uniform. In the region of the elongate cells, the nidi are fairly large and numerous but they are much smaller and often very sparse in the region of the shórt cubical cells.

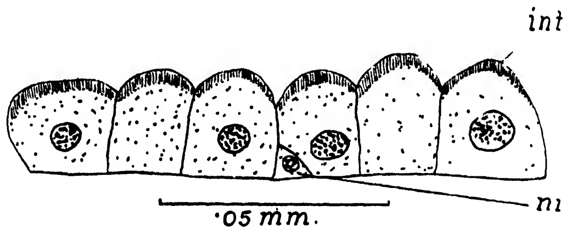

FIG. 9.—Portion of epithelium (L.S., young and undifferentiated) from the mid-gut: lettering as in Fig. 7.

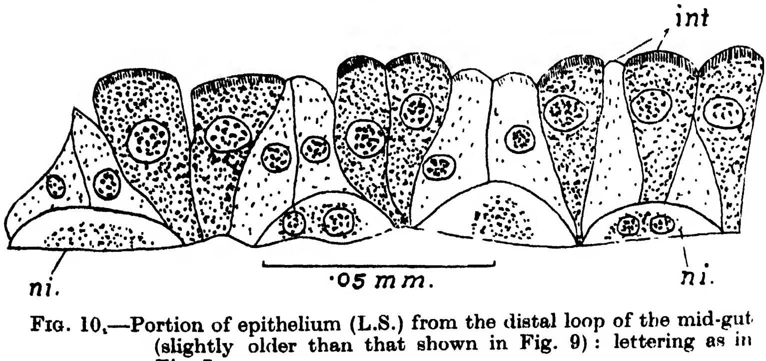

FIG. 10.—Portion of epithelium (L.S.) from the distal loop of the mid-gut (slightly older than that shown in Fig. 9): lettering as in Fig. 7.

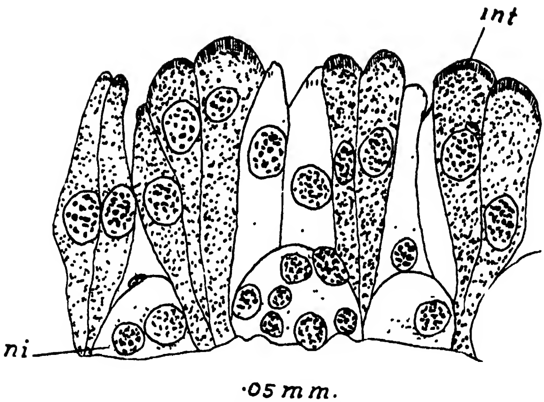

FIG. 11.—Portion of epithelium from the distal loop of the mid-gut: here the differentiation has gone further: lettering as in Fig. 7.

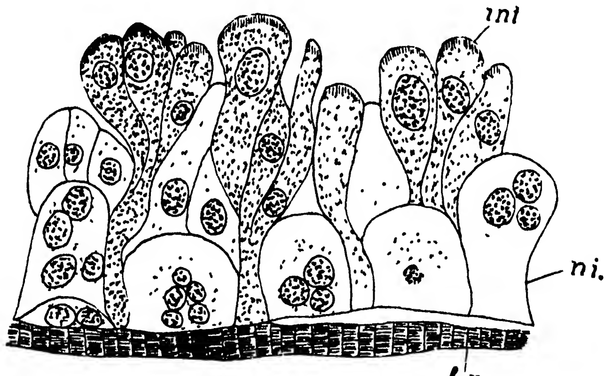

FIG. 12.—Portion of epithelium from the distal loop of the mid-gut: here the differentiation has gone still further: lettering as in Fig. 7.

Another peculiarity of the distal loop epithelium is that the tall cells are differentiated apparently into two distinct kinds, one kind of cells staining much more deeply than the other. The deeply staining cells vary in shape; some are goblet-shaped (fig. 10), others club-shaped (fig. 11), and still others are so much drawn out as to rest on elongated peduncles (fig. 12). The lightly staining cells, on the other hand, are generally broader at their base, although they vary considerably in their height. The differences in the shape and grouping of the deeply staining cells give different appearances to the epithelium of the various

regions as seen in sections. When the pedunculate cells are situated in small groups on the top of the nidi, they look like regularly arranged flower-bouquets (fig. 12), and give a pretty appearance to the whole epithelium of the region.

The epithelium shows these characters very nearly up to the posterior end of the mid-gut. At the extreme posterior end, however, the epithelial cells become particularly tall and narrow, and often reach almost the centre of the lumen, specially so, near the origin of the malpighian tubules where they become so compact in addition that in sections the epithelium often appears to consist of several layers of cells (fig. 13).

We may note that the differentiation of the tall elongate cells into two kinds as described above, has not been noticed either by Potts or by Burgess in *E. corrupta*.

The pyloric valve.—The pyloric valve (figs. 13; and 13*a* Pl. 4) lying at the junction of the mid-gut and the hind-gut, results

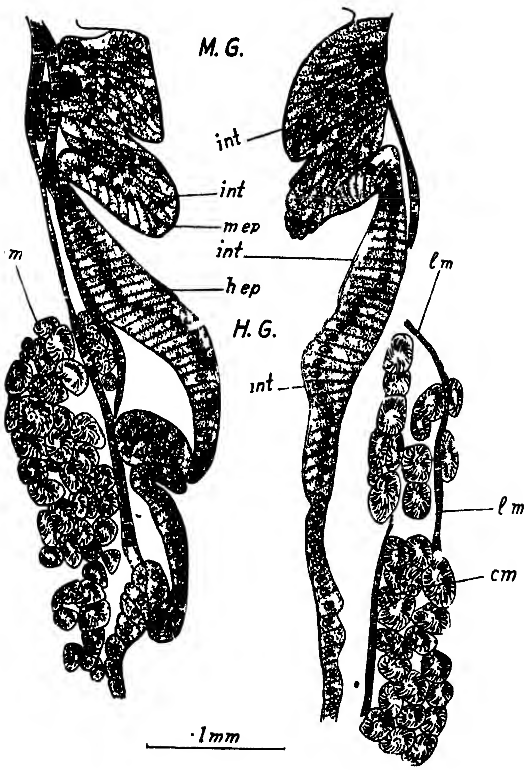

FIG. 13.—L.S. through the pyloric valve: *c.m.*, circular muscles; H.G., hind-gut; *int.*, intima; *l.m.*, longitudinal muscles; M.G., mid-gut; *m.ep.*, mid-gut epithelium; *h.ep.*, hind-gut epithelium.

by a slight telescoping of the mid-gut into the hind-gut and thus leads to the formation of a space round the distal extremity of the mid-gut. Both the inner and outer walls of the valve consist of elongated, compactly placed and rather deeply staining epithelial cells like those of the mid-gut, but at the place where the outer wall of the pyloric valve passes into the wall of the hind-gut, the nature of the epithelium changes considerably; here the epithelium consists of closely fitting narrow columnar cells lined with a very thin intima which is probably chitinous. The musculature of the gut just round the valve is remarkably ill-developed, there being no circular muscles in this region.

Another peculiarity to be noticed in this region is, that opposite the point of entrance of each malpighian tubule, there is a definite pad [1] on the inner wall of the pyloric valve. These pads as seen in the microphotograph (fig. 25, Pl. 4) are oval in transverse section and more or less reticulate in structure.

About 110 microns behind the pyloric valve, the circular muscles are very strongly developed (fig. 21, Pl. 4) and, in fact, form a thick sphincter up to 80 microns in thickness. The epithelial cells are essentially similar to those at the junction of the pyloric valve and the hind-gut. Sometimes, however, the epithelium looks, in serial sections, like a syncytium rather than a cellular epithelium. All these changes which have been described in this 'transition zone' take place within a short length of about ·35 mm.

The accounts of this transition zone, specially those of the pyloric valve, given by the two workers on the same species, i.e. *E. corrupta* are surprisingly contradictory; Potts (1927) writes, 'No typical pyloric valve occurs in the gut of *E. corrupta*'. Burgess (1932), on the other hand, without expressly contradicting Potts, writes, 'The pyloric valve is very well-developed. Grossly it is a long structure placed in the tract in a manner similar to that of the "sections" in an orange. There are six of these sections and when viewed in cross-section they appear as six lobes extending into the lumen of the hind-intestine. These ridges occur in one form or another all along the proctodæum . . . The most prominent layer in the pyloric region is the layer of the circular muscles that is found outside the basement membrane. This layer of muscles is probably the most outstanding muscle layer in the whole of the alimentary canal.' From this description of the pyloric valve given by Burgess, there seems little doubt that Burgess has mistaken the sphincter lying behind the region of the actual valve for the valve itself.

The hind-gut.—Structurally, the hind-gut differs from the mid-gut, firstly, in the re-appearance of the chitinous intima which characterizes the fore-gut, secondly, in the non-glandular but compact nature of its epithelial lining, thirdly, in the absence

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[1] I have not seen such pads described elsewhere.

of the nidi, and fourthly, in the special development of the muscles in certain regions. These differences are described in detail below.

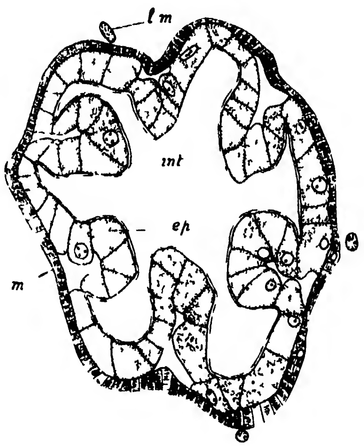

FIG. 14. T.S. through the ileum (anterior portion) : *c m.*, circular muscles ; *ep.*, epithelium ; *int.*, intima, *l.m.*, longitudinal muscles.

The ileum.—Posterior to the sphincter which extends about 215 microns in length, the nature of the epithelium changes again. The cells assume the typical character of the hind-gut epithelium, which is thrown into six typical longitudinal folds (fig. 14), though sometimes a few additional invaginations are also observed. The cytoplasm of the cells is finely granular, unlike that of the cells of the mid-gut, where it is coursely granular.

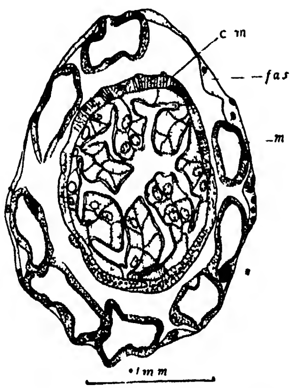

FIG. 15.—T.S. through the ileum (posterior portion) : *fas.*, fascia ; *m.t.*, malpighian tubules ; rest as in Fig. 14.

The nuclei are much better defined in their outline than those of the cells of the mid-gut ; the chromatin granules become bigger in size but lesser in number as we travel backwards ; the intima is fairly thick and chitinous. The musculature is moderately well-developed

At the hind end of the ileum (fig. 15), the malpighian tubules enter the fascia and surround the wall of the gut The fascia in this region becomes quite distinct and forms an envelope over the malpighian tubules surrounding the gut. The epithelial folds become well-defined and compact, and in transverse sections some of them appear to be almost sessile buds with very short and narrow necks The musculature and the intima remain more or less unchanged

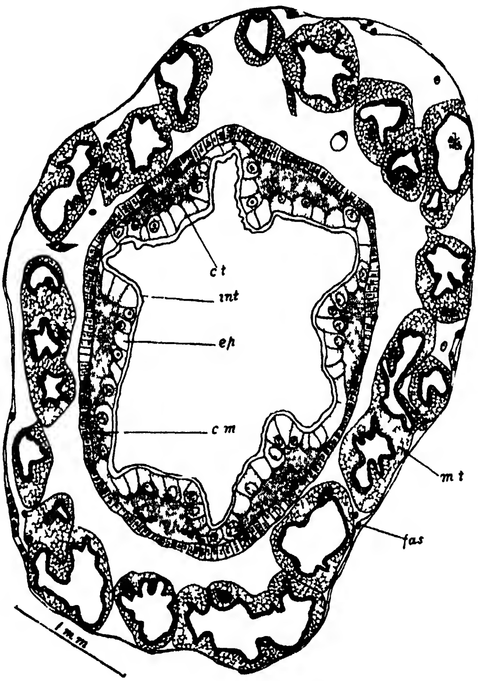

FIG. 16.—T.S. through colon : *c.t.*, connective tissue : rest as in Fig. 19.

The colon.—In the colon (fig. 16) the epithelial folds open out again and in transverse sections, appear as flat invaginations. The space within these folds are filled with a kind of hyaline connective tissue (*c.t.*). The intima becomes more compact and stains more deeply. In sections, the malpighian tubules surrounding the colon appear to be more numerous than in the posterior portion of the ileum ; this is due not to a real increase

in their number but to their zig-zag course, on account of which they are cut several times in the same section.

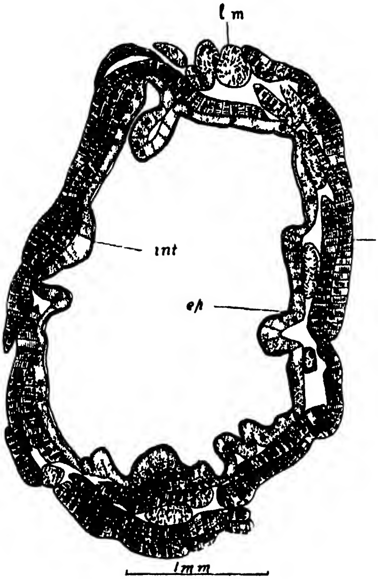

FIG. 17 —T.S through rectum : lettering as in Fig 14

The rectum.—Structurally, the rectum (fig. 17) appears to be an elongated sphincter. The cell outlines are indistinct but the nuclei stain prominently, there being almost always only one big compact chromatin granule in each nucleus. The circular muscles are very well-developed and form a sphincter.

4. ACTIVITY OF THE MID-GUT EPITHELIUM.

The remarkable peculiarities of the alimentary canal of *E indica* concern the activities of the mid-gut epithelium. The earliest classical work concerning these activities is that by Van Gehuchten (1890) on *Ptychoptera contaminata*. He distinguished two definite kinds of cells, secretory and absorbtive, in the ventricular epithelium of this fly. He concluded that the 'globular protrusions' found on the top of certain epithelial cells were secretory globules. He also mentioned that sometimes these globules carried the nuclei also with them. Most of the later workers till 1930 have taken Van Gehuchten's conclusions for granted and have busied themselves in deciding whether the two kinds of cells distinguished by Van Gehuchten as secretory and absorbtive are the same or are different morphological units.

During this period of nearly half a century, only Newcomer (1914) and Pavlovsky and Zarin (1922) seem to have deviated from the general conclusions enunciated by Van Gehuchten. Newcomer only suspected but Pavlovsky and Zarin definitely concluded that the so-called secretory globules are mere artefacts. H. Henson (1930), however, for the first time seriously contended that the 'so-called merocrine method of secretion of the gut cells may not be a secretion process at all'. He favours the alternative view that the formation of secretory vesicles is really a process of cell disintegration due to wear and tear or to the incidence of metamorphosis. Recent tendency is to favour Henson's contention. I do not propose to enter into the controversy as to whether the activities of the mid-gut epithelium are secretory or are of the nature of disintegration processes but I am confining myself to the relation between the different processes and also their effect on the visible structure of the epithelial cells.

Potts (1927) does not describe any particular mode of secretion in *E. corrupta*; Burgess (1932) working on the same species describes the secretion as being of 'a modified holocrine type'. He says that 'the ends of the secreting cells' are constricted and pinched off as 'balls of digestive fluid'. 'In no case was the nucleus of the secreting cell found in the globule that was secreted.' In *E. indica* on the other hand, the contents of the epithelium enter the lumen in the following ways :—

(1) as non-nucleated vesicles,
(2) as individual cells squeezed out in their entirety into the lumen ;
(3) as delaminations of the portions of the gut epithelium ;
(4) as streams of nuclei from the nidi.

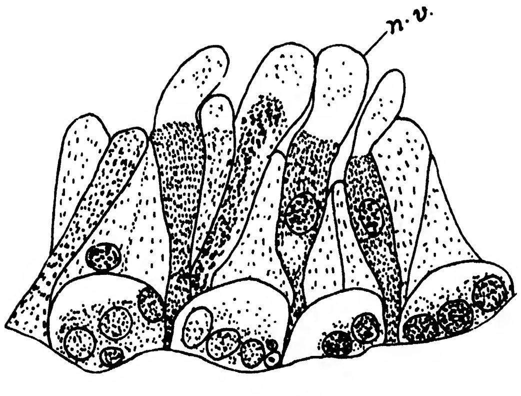

FIG. 18*a*.—Portion of epithelium (T.S.) from the distal loop of the mid-gut showing the non-nucleated vesicles (*n.v.*).

(1) *Non-nucleated vesicles.*—This process (figs. 18*a*; and 18*b*, Pl. 4) has been observed by me only in the distal loop of the mid-gut. Clear vesicles full of some fluid bulge out from the top of the deeply staining club-shaped cells and either simply burst to let out the contents or are pinched off as small globules. This process is the 'merocrine' type of secretion of Haseman (1910)—a process which has been described by many workers on the alimentary canal ever since Van Gehuchten described it in *Ptychoptera contaminata* in 1890.

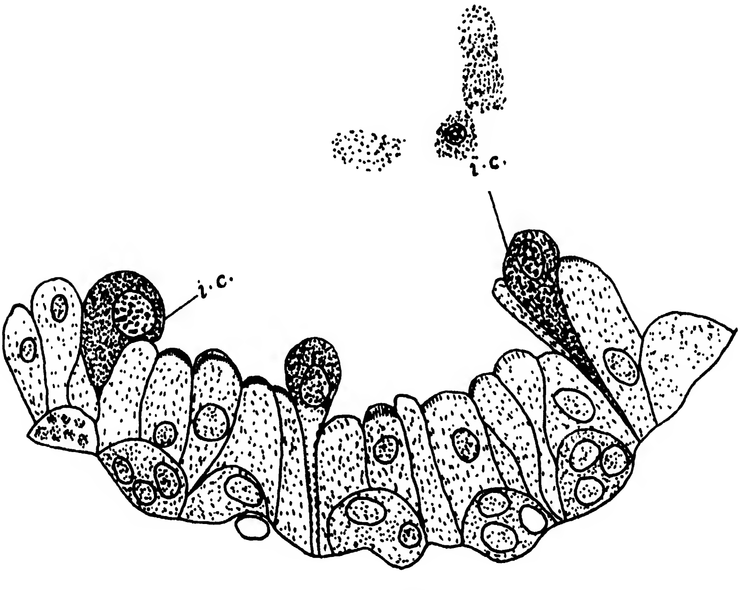

FIG. 19*a*.—Portion of epithelium (T.S.) from the distal loop of the mid-gut showing the 'squeezing out' of individual cells (*i.c.*).

(2) *Squeezing out of individual cells.*—In this process, the individual cells are simply squeezed out into the lumen. Here the cells gradually break up and get mixed up with the gut contents. This is the 'holocrine' type of secretion of Haseman and has also been described in several insects, as for example in the dragon-fly nymphs by Needham (1897) and in *Tabanus* by Cragg (1920). I have observed this process in all its stages in the distal loop of the mid-gut (figs. 19*a*; and 19*b*, Pl. 4).

(3) *Delaminations of portions of the epithelium.*—During this process, large portions of the epithelium are simply sloughed off into the lumen, leaving behind a few nidal nuclei, which afterwards regenerate the sloughed off epithelium. The delamination of the mid-gut epithelium at the time of moulting has been

described by various investigators and it appears that it is a common occurrence amongst insect larvæ, but in the adult insect, this phenomenon has been described only in a few water-beetles. Haseman (1910) says that Frenzel ('85), Vangel ('86), Bizzozzero ('93) and Rengel ('97) have described epithelial degeneration and regeneration in adult water-beetles of the genera *Hydrophilus*, *Hydrobius*, *Hydrous* and *Cybister* respectively. 'In these beetles the entire epithelium with its basal chitinous membrane is described as being cast off after each full feeding. The new epithelium is quickly developed from highly specialized regenerating centres or nidi.' Wigglesworth (1929) writes in the case of the tse-tse fly, 'At times there is a considerable break down of the epithelium and this is regenerated subsequently'. Burgess (1932) describes a 'curious splitting of the epithelium' in the anterior region of the mid-gut of the hibernating *E corrupta* and contends that it cannot be an excretory function as in the moulting *Collembola* described by Folsom and Welles (1906). Burgess regards it possibly as 'a mechanism to keep the animal nourished during its hibernating

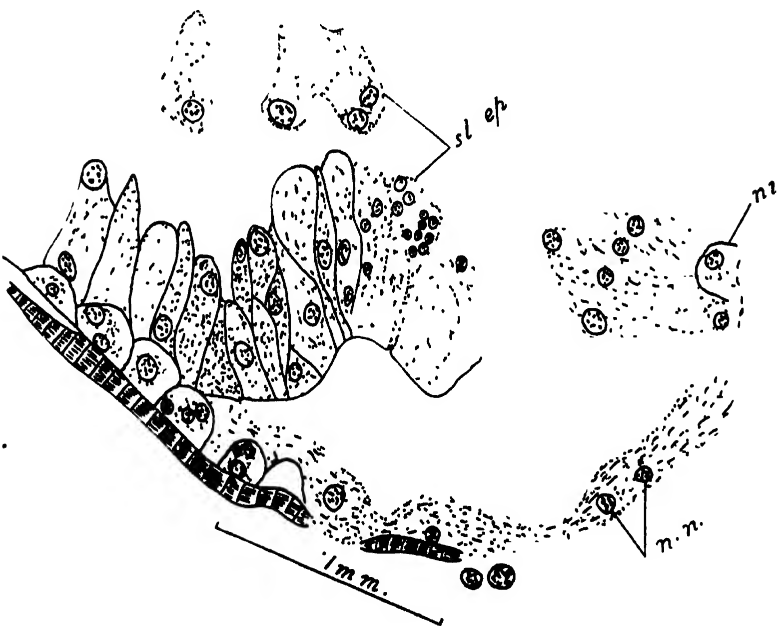

FIG. 20*a*.—T.S. through the anterior portion of the proximal lobe, showing the 'sloughed off epithelium (*sl.ep.*)'; *n.n.*, nidal nuclei.

period'. In *E. indica* on the other hand, this process (fig. 20*a*, 20*b* and 20*c*, Pl. 4) is a common occurrence in the adult

feeding stage, and cannot be interpreted as in *E. corrupta* to be a nourishing ' mechanism ' in the absence of normal food.

(4) *Streams of nidal nuclei.*—In this process (figs. 21 and 22*a*; 22*b*, Pl. 4) the nuclei from a nidus enter the epithelial cells next

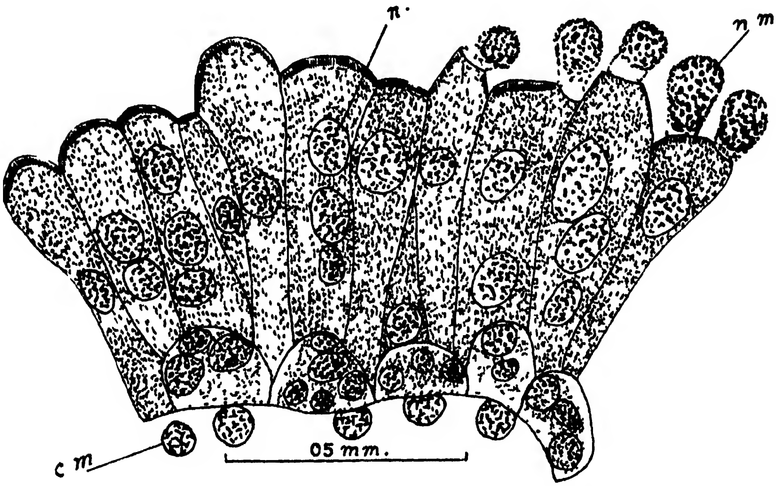

FIG 21 —Portion of epithelium (L S) from the anterior part of the proximal lobe showing the extrusion of the nuclear material : *n m*, nuclear material, rest of the lettering as in Fig 7

to it and migrate towards the lumen through the length of the epithelial cells, on reaching the inner ends of the cells, the nuclei are either pinched off into the lumen as nucleated masses of cytoplasm or are poured out as nuclear material into the lumen through a definite, circular and comparatively large aperture on the inner border of each epithelial cell As clearly seen in the microphotograph (fig 22*b*, Pl. 4) the nuclei can be followed in all the stages in their migration from the nidus to the lumen of the gut This process is met with in the anterior portion of the proximal lobe A process of this kind, so far as known to me has not been described in any other insect.

Thus almost all the processes, by which the contents of the epithelium are discharged into the lumen in different insects, can be observed in the same series of sections in *E indica* Due to this co-existence of the different processes, it becomes easy to observe the gradation and also to interpret the relations between them. A careful study of these processes renders it clear that all of them are really different phases of the same process. In the newly formed epithelium all the cells are more or less alike (fig. 9) and the nidi between them are either small and flat or are represented even by single interstitial cells (*ni.*). A little later the nidi grow to a bigger size and become more

convex in shape, while the epithelial cells get differentiated into deeply staining club-shaped cells and the lightly staining cells

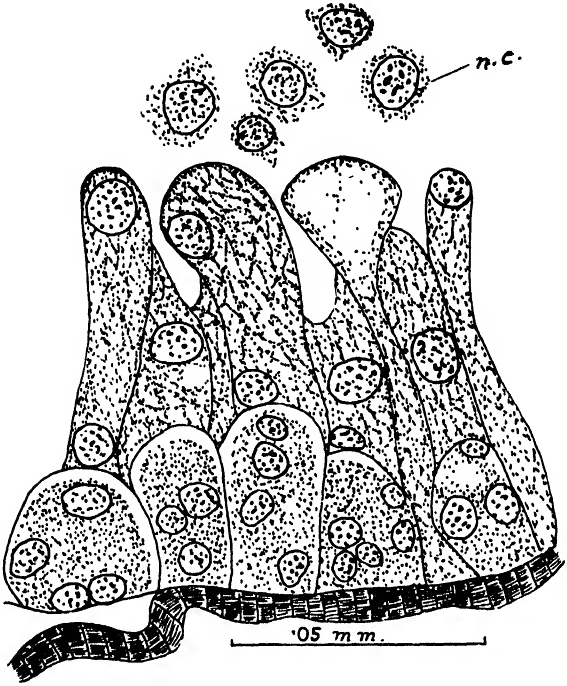

FIG. 22*a*.—Portion of epithelium from the anterior region of the proximal lobe (T.S.) showing 'nuclear migration' and throwing off of the nucleated masses of cytoplasm (*n.c.*).

with broader bases. This differentiation of the epithelial cells is probably brought about by an increase of pressure at the bases of the older cells caused by an addition of new cells from the nidi. /The greater affinity for stains exhibited by the club-shaped cells seems to be due to a larger accumulation within these cells of secretory or excretory products. Thus it would appear that the deeply staining club-shaped cells in *E. indica* differ from the faintly staining cells only in age. This leads us to the conclusion that the two kinds of the cells distinguished by Van Gehuchten as secretory and absorbtive are the same cells at different stages of development.

An examination of the gradations from the simple club-shaped cells to those capped with non-nucleated vesicles leads us to believe that the formation of these vesicles is a result of a further increase of pressure on the sides of the club-shaped cells caused by the same activities of the nidi as are responsible for

the club-shaped appearance of these cells. It appears equally probable that the second process referred to above, i.e. the squeezing out of the individual cells in their entirety is also a consequence of the continued increase in pressure on the cells even after the formation of vesicles. Thus the first two processes are simply the two phases of the same process. It is but natural to conclude that a gradual increase of pressure will squeeze out first the more fluid content of the cell and then the cell itself. It is, however, also possible that sometimes due to a sudden and quick increase in pressure, the first phase may be completely eliminated and the cells may directly enter the second phase.

The gradation from the second to the third process, i.e. from the squeezing out of individual cells to a delamination of epithelial portions is easily seen in the anterior region of the mid-gut. One can often observe that instead of the individual cells being squeezed out, large groups of cells are vigorously cut off into the lumen. It is easy to imagine that this process is merely a more vigorous and violent stage of the second process described above; and from this process, one is easily led to a stage where both the first and the second processes are completely eliminated and large portions of epithelium are simply sloughed off into the lumen. The fourth process, i.e. the migration of the nidal nuclei, is also a modification of the normal process of regeneration. The nidi instead of supplying well-defined cells, are supplying the nuclei only, the formation of separate masses of cytoplasm and cell-separations being masked due to the extraordinarily vigorous activity of the nidi. All the same this process of sending streams of nuclei into the lumen throws some light over the disputed function of the nidi. Ordinarily the nidi have a regenerative rôle, but the streaming of their nuclei into the lumen of the mid-gut suggests a glandular function also. It may be pointed out in this connection that the nidi have already been suspected to be glandular in several cases and have therefore been named '*drusen crypton*' by several workers.

5. Peritrophic membrane.

The study of the sections through the mid-gut of *E. indica* also throws some light on the efficiency of the peritrophic membrane. The peritrophic membrane was not found by me in all the transverse sections of the mid-gut. The epithelial cells discharged from the mid-gut epithelium are sometimes found mixed with the food material. Some longitudinal sections show shreds of peritrophic membrane which reveal a fenestrated structure (fig. 23, Pl. 4). These observations point to the conclusion that the peritrophic membrane while present in the major part of the mid-gut does not form a complete partition between the products of the epithelium and the food material.

6. Functions of the Œsophageal and Pyloric Valves.

From the structure and position of the œsophageal and pyloric valves, one is led to conclude that the closure at these junctions is not effected by the valves themselves but by the sphincters, one lying in front of the œsophageal valve and the other behind the pyloric valve. These so-called valves[1] are not valves in the strict sense of the term, preventing the contents of the mid-gut from passing into the fore-gut and those of the hind-gut into the mid-gut. The following considerations seem to justify the above-mentioned conclusions :—

If the œsophageal valve did really have a valvular action, the closure of the valve would be effected by a pressure of the contents of the gut round the valve between it and the wall of the mid-gut.[2] Such a pressure cannot be produced because, in the first place, the œsophageal valve is a well-developed double-walled structure strengthened by chitinous intima, while the wall of the mid-gut round the œsophageal valve is generally much weaker than the valve itself; if, therefore, the food exerts a pressure between the valve and the wall of the mid-gut, it is the latter that will bulge out rather than that the valve will be closed. Secondly, as the gastric cæca generally open in the annulus round the œsophageal valve, no pressure will be exerted in this region, unless the gastric cæca are also filled with the gut-contents and even then the gastric cæca will burst before the valve is pressed. Thirdly, if the closure between the fore- and the mid-guts were valvular, the secretion would be as much prevented from entering the fore-gut as the food-contents of the mid-gut from regurgitation ; but it has been already observed by previous workers and I have confirmed their observations that the secretory globules of the mid-gut actually do pass into the fore-gut.

These considerations against the valvular action of the œsophageal valve are equally true in the case of the pyloric valve also. In place of the gastric cæca opening round the œsophageal valve, we have here the malpighian tubules opening round the pyloric valve. But, in the case of the pyloric valve I have never seen the contents of the hind-gut passing into the mid-gut.

On these grounds, I think that the terms 'Oesophageal and Pyloric Valves' are unfortunate misnomers. The question still

[1] Wigglesworth (1930) while describing the formation of the peritrophic membrane in mosquito larvæ makes the following remark :—'At this point the œsophagus is invaginated into the mid-gut to form the structure usually referred to as the "œsophageal valve", an unfortunate term, that attributes to this part of the intestine a property which it does not possess, for the invagination acts not as a valve but as a sphincter.' Q.J.M.S. (1930); p. 594.

[2] Kawalevsky (1887) has also stated in the case of a muscid larva that no food enters the annulus round the œsophageal valve.

remains as to what their function or functions are. I believe that the functions of these valve-like folds are: firstly, to shut[1] off an annular space round the valves for the opening of the glands (gastric cæca and malpighian tubules), so that the openings of these glands are prevented from being clogged by the food-contents; secondly, to act as a means of mechanical safety at the junction of two different parts of the gut.

7. The malpighian tubules.

The malpighian tubules are six in number. At their origin they are symmetrically placed and as already described, open separately at the anterior end of the annular space round the pyloric valve. A little beyond their origin they begin to surround the proximal lobe of the mid-gut and extend in the anterior direction on a very zig-zag and convoluted course, some reaching right up to the very base of the crop, whence they turn back to travel the same course along the proximal lobe, reaching again the level of their origin or in some cases even much posterior to that. Here they form two groups of three each and enter the fascia of the posterior region of the ileum. Beneath the fascia, they travel posteriorly, surrounding the colon much more intimately and in a much more convoluted manner than they do in the proximal lobe.

Posteriorly the malpighian tubules end blindly at the junction of the rectum and the colon within the fascia.

In a transverse section, a malpighian tubule consists of two or three cells surrounding a central lumen. The size of the cells appears to depend on their physiological activity. At some places, the cells are quite plump and bulge inwards so as to obliterate the lumen; at other places, the condition is reversed, i.e. the cells are contracted and the lumen is large. The cytoplasm of the cells is finely granular and shows a reticulate structure under the high power of the microscope. The nuclei are fairly large and well-defined, and stain deeply. The inner borders of the cells are beset with well-developed cilia which can be clearly seen projecting into the lumen.

If a slightly anæsthetized specimen is dissected in normal saline solution, the movement of the malpighian tubules can be studied with great interest. In a fresh dissection, some portions of the malpighian tubules look quite translucent, while others are sometimes opaque white. These opaque white portions contain solid white excretory products collected together in flexible rods lying within the lumen of the tubules. At times it is interesting to see solid excretory rods being moved quickly in periodic jerks within the lumen. This movement is most

[1] This view has already been taken by Snodgrass (1935) in the case of the œsophageal valve.

probably effected by the cilia just described. This solid excretory material is often seen cut in transverse sections. The presence of calcium carbonate in the form of small granules or large calcospherites has been described by many writers in insect larvæ but in the adult insect, the presence of calcium carbonate has been observed only in *Drosophila funebris* by Eastham (1925); I have not found the condition observed in *E. Indica* described anywhere before.

8. THE SALIVARY GLANDS.[1]

There is a pair of salivary glands in *E. indica* (fig. 24). They are very fine tubular structures and consist of a chitinous tube

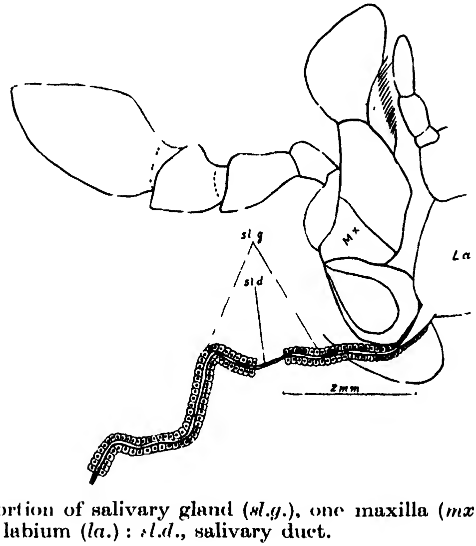

FIG. 24.—Portion of salivary gland (*sl.g.*), one maxilla (*mx.*) and part of labium (*la.*) : *sl.d.*, salivary duct.

surrounded by a single layer of almost cubical cells. They open separately in the angles between the labium and the maxillæ, beneath the sides of the hypopharynx.

[1] The credit of observing these glands for the first time in the family Coccinellidæ goes to my friend Mr. R. L. Gupta. The American workers on *E. corrupta* have not described the salivary glands at all but we have found them in all the species of Coccinellidæ we have dissected.

N.B.– Further investigations after sending this paper to the press reveal that these glands are not true salivary glands, homologous with the labial glands of a generalized insect. These glands are the maxillary glands. Besides these there are other glands also which are true labial glands associated with the labium proper.—Pradhan (1937), *Cur. Sc.*, May 1937.

9. Material and Technique.

Specimens of *E. indica* are abundant in Lucknow during the months of August, September and the first half of October, when they can be collected in fields containing Cucurbitaceous plants, specially *Cucumis melo* var. *utilissimus*. For the present investigation, these insects were either brought fresh from the fields or were reared in the laboratory on cucumber leaves.

The insects were anæsthetized in KCN tubes and were at once dissected in normal (·75%) saline solution. Different fixatives were tried but Bouin and Carnoy were found to be most satisfactory.

In cutting sections of the mid-gut and the hind-gut, simple embedding in paraffin wax was quite sufficient but in the case of the fore-gut double embedding (celloidin and paraffin wax) method was to be resorted to.

The stains used were Delafield hæmatoxylin, iron hæmatoxylin, and borax-carmin for the nuclei and eosin, indigo-carmin and orange G. for the cytoplasm.

The drawings were made with the help of the camera lucida.

Acknowledgments.

With great respect I wish to record my grateful thanks to Prof. K. N. Bahl, whose direct supervision, kind guidance and painstaking criticism have been very helpful in this investigation. His keen interest in the progress of the work has been a constant source of encouragement to me. I have also received considerable help and valuable criticism from Dr. H. S. Pruthi, Imperial Entomologist at the Imperial Institute of Agricultural Research, Pusa and I respectfully record my indebtedness to him. I am also very grateful to M. L. Bhatia, Esq., Lecturer in Zoology in the University of Lucknow for his kind help in various ways. My thanks are also due to the University of Lucknow for the grant of a Research-Fellowship for this piece of work.

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N.B.—I have not seen the papers marked with * but I have referred to them on the authority of the quotations given by other authors.

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Explanations to Plate 4

Fig. 23.- A shred of the peritrophic membrane from the L.S. of the mid-gut (microphotograph).

Fig. 25.— T.S. (oblique) through the pyloric valve: (microphotograph); *h.ep.*, hind-gut epithelium; *m.ep.*, mid-gut epithelium; *pa.*, pad; *m.t.*, malpighian tubule.

Fig. 20*b*.— T.S. through the anterior portion of the proximal lobe showing the shedding off of groups of cells (*sl. ep.*) a transition between the 'squeezing out' of individual cells and the sloughing off of the epithelium: (microphotograph).

Fig. 20*c*.- T.S. through the distal loop of the mid-gut showing the sloughed off epithelium (*sl. ep.*) within the lumen: (microphotograph).

Fig. 13*a*.—T.S. through the region of the sphincter behind the valve; (microphotograph); *c.m.*, circular muscles; *ep.*, epithelium.

Fig. 22*b*.—Portion of epithelium from the anterior region of the proximal lobe (T.S.) showing the 'nuclear migration' and the throwing off of the nucleated masses of cytoplasm: (microphotograph); lettering as in Fig. 22*a*.

Fig. 19*b*.— T S. from the distal loop of the mid-gut showing the squeezing out of individual cells (*i.c.*): (microphotograph); *f.c.*, food cylinder.

Fig. 18*b*.— Portion of epithelium (T.S.) from the distal loop of the mid-gut showing the non-nucleated vesicles (*n.v.*): (microphotograph).

Fig 23

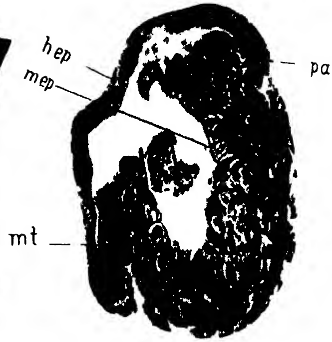

Fig 25

Fig 20b

Fig 20a

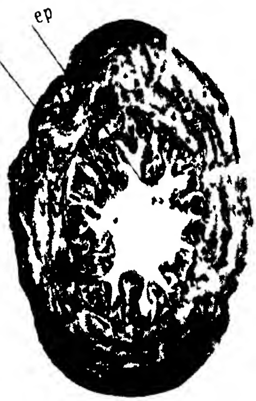

Fig 13a

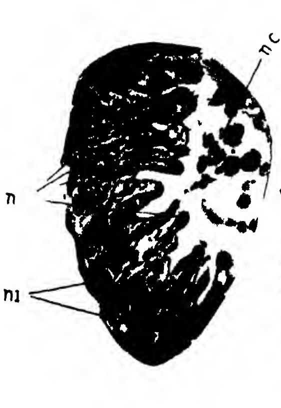

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Fig 18b

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ARTICLE NO. 6.

Abnormalities in Fishes.

By D. D. MUKERJI *and* K. KRISHNAN NAIR.

(Communicated by Dr S L Hora, and published by permission of the Director, Zoological Survey of India.)

1. On a Brown Trout (*Salmo fario* Linn.), showing eversion of stomach into the pharyngeal cavity.

By D. D. MUKERJI.[1]

In January, 1936, the Zoological Survey of India was informed by the Divisional Forest Officer, Kagan Forest Division, Hazara District, N.W.F.P., of the very high mortality of fry in the local brown trout hatcheries; it was also stated that fishes over three years old die in fair numbers every now and then. To elucidate the cause of the mortality, the Divisional Forest Officer was requested to send properly preserved specimens of the fish and supply information regarding the ecological conditions under which the fish live. Unfortunately, no information was received except for 'a dead fish duly preserved in a 5% solution of formalin', which forms the basis of this note. This specimen is an adult male of *Salmo fario* Linn. with mature gonads, and is 15½ inches in total length. From its general appearance it seems to be a normal and healthy individual exhibiting no external abnormalities. A superficial examination of the specimen also revealed no apparent cause of death. On opening the pharynx of the specimen by cutting laterally through its left wall, a massive thumb-shaped structure, which at first sight appeared to be a large tumour or hernial sac, was, however, found lying in its cavity. A closer examination showed that this structure was formed as a result of the complete eversion and prolapsus of the proximal loop or the broad cardiac portion of the siphonal stomach into the pharyngeal cavity. The structures immediately following, viz., the spleen, the distal loop or the pyloric portion of the stomach, the duodenum, the pyloric cæca, the fat-bodies and some portion of the intestine are, as a result, pulled forwards and inwards and drawn into the everted sac in front of the gullet which also is everted and forms the posterior end of the sac. In view of the peculiar disposition of the various organs a detailed account of these abnormalities is

[1] It may be noted that the author died before the paper was actually sent to the press, so the proofs were corrected by Dr. S. L. Hora.—*Editor*.

given below, and reference is also made to the probable mode of the ingestion of food in such abnormal specimens.

Attention may here be directed to a more or less similar abnormality recorded by Mudge [1] in a specimen of the dog-fish, '*Scyllium canicula*' (-*Catulus caniculus*).

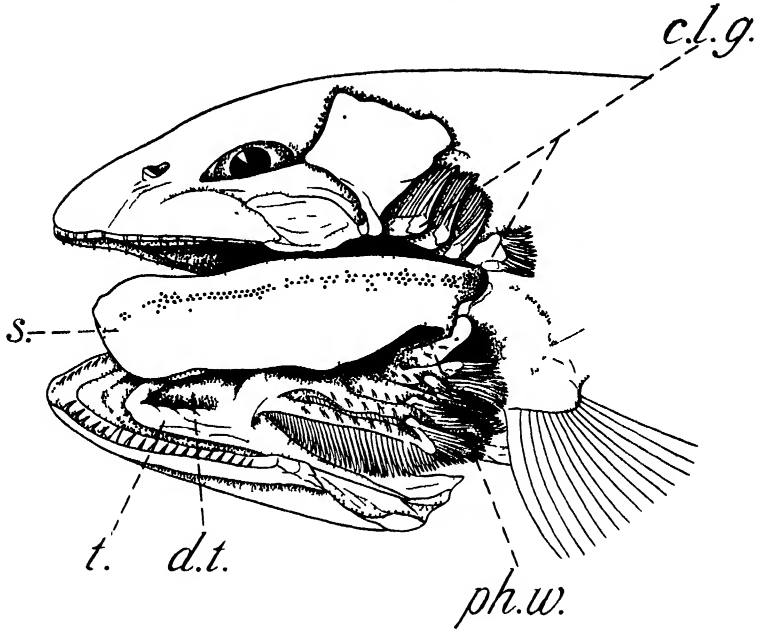

FIG. 1.—The left wall of the pharyngeal cavity of the abnormal trout cut open laterally to show the structure and position of the sac formed by eversion of proximal loop of stomach. ×⅘

c.l.g., cut portion of left gills, *d.t.*, depression on tongue, *ph.w.*, pharyngeal wall, *s.*, sac formed by eversion of proximal loop of stomach; *t.*, tongue

Description.—The sac (text-fig. 1, *s.*) the outer wall of which represents, from behind forwards, a confluence of the everted inner walls of the gullet and of the proximal loop of the stomach, extends horizontally over and beyond the tongue (*t.*). It is somewhat tough, smooth and swollen. The structure is elongated, slightly depressed and 80 mm. long, 30 mm. broad and 20 mm. deep. It is broadly rounded anteriorly, deepest in the middle and rather constricted posteriorly, where it is lined by the pharyngeal wall (*ph.w.*). On cutting open the pouch laterally through its left wall (text-fig. 2, *p.l.st.*) past its attach-

[1] Mudge, Geo. P.—*Proc. Zool. Soc. London*, II, p. 490 (1905); *Zool. Anz.*, XXX, pp. 278–280, 1 fig. (1906).

ment with the pharyngeal wall, the spleen (*spl*.), the distal loop of the stomach (*d l st*.), the duodenum (*du*.), the pyloric cæca

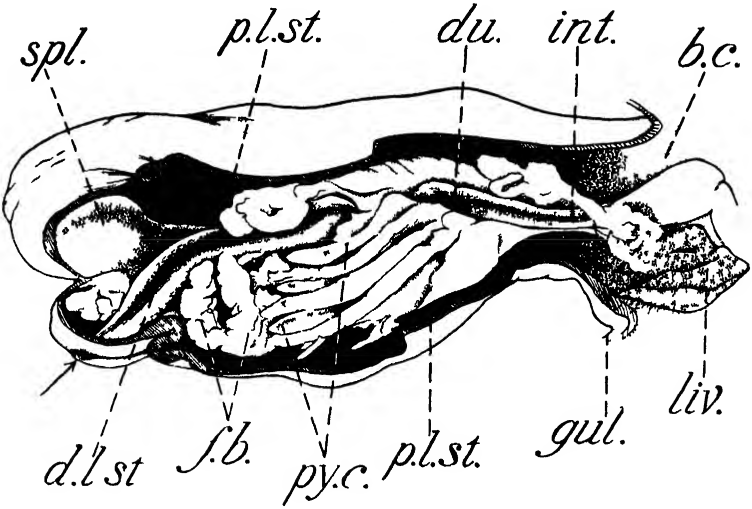

FIG. 2.—The sac formed by eversion of stomach cut open laterally through its left wall to show the disposition of structures within it *in situ*. *Same size.*
b c., body cavity; *d l st*., distal loop of stomach; *du*., duodenum; *f b*., fat bodies; *gul*., everted gullet; *int*., intestine; *liv*., liver; *p l st*., proximal loop of stomach; *spl*., spleen; *py c*., pyloric cæca.

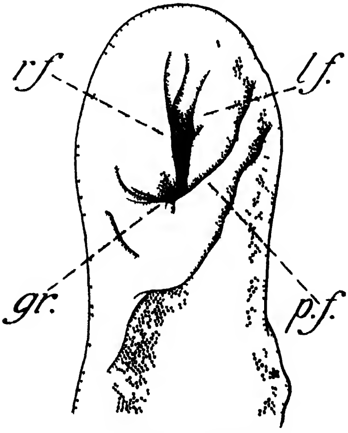

FIG. 3.—Ventral view of the sac showing the position of the invaginated median groove and the associated labiate folds. *Same size.*
gr., groove; *l f*., left lateral fold; *p f*., posterior transverse fold; *r f*., right lateral fold.

(*py.c.*), the fat-bodies (*f.b.*) and a portion of the intestine (*int.*) are seen lying within the sac. As a result of eversion, an orifice is formed at the posterior end of the sac which opens into the body cavity (*b.c.*). Through this orifice the intestine, which is obviously pulled forwards roughly by twice the length of the everted sac, passes out into the body cavity and is continued along its normal course to the anus. The rest of the digestive organs behind the everted gullet (*gul.*) are normal, but the liver (*liv.*) is pulled forwards and comes to lie immediately behind the orifice

A close examination of the outer surface of the seemingly closed everted sac revealed the existence, ventral to its anterior end (this position is indicated by an arrow in text-fig. 2), of a somewhat elongated (22 mm. in length), gaping slit or an invaginated median groove (text-fig. 3, *gr.*) bordered by a number of fairly deep folds and furrows. Of these, the right (*r.f.*) and the left (*l.f.*) lateral folds are thick, labiate and well defined The posterior portion of the groove is partially roofed over by another broad subcrescentic, lip-like transverse fold (*p.f.*). In its normal position the groove lies superimposed over the normal depression of the tongue (text-fig. 1, *d.t.*). On passing a probe into the groove it was found to lead into the distal loop of the stomach which extends to the anterior end of the sac. Thus the groove appears as a 'pseudo'-gullet. In view of the fact that the proximal loop of the stomach is turned inside out over the distal loop, an invaginated groove of this nature appears to have been formed between and near the junction of the two loops.

Remarks.—The abnormalities observed by Mudge in the disposition of the lieno-gastric and the coeliac arteries must, *per se*. lead to the conclusion that the eversion of the stomach in the dog-fish was 'permanent' and that 'at quite an early stage of differentiation of the primitive gut, the proximal loop of the stomach probably became gradually everted . . . . .'

The poor condition of the abnormal trout under report did not permit a detailed study of the arteries that supply the stomach and the spleen and it is, therefore, not possible to state definitely whether it represents a permanent abnormality similar to that recorded by Mudge, or a case of a sudden eversion which might have caused the death of the fish.[1] The condition of the other structures described above is, however, very similar to that observed by Mudge in the abnormal dog-fish.

Accepting Mudge's observations and admitting that the 'dog-fish must have lived with the inner surface of its stomach

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[1] Dr. Hora is, however, of the opinion that it represents a case of sudden eversion which caused the death of the fish through asphyxiation, for he believes that the abnormal disposition of the various organs described above is likely to interfere with the mechanism of normal respiration.

turned inside out and everted into the pharyngeal cavity', the question of the course of food in the abnormal specimen has to be considered. Mudge noted that 'the animal was fully nourished and the ovary was of normal size and laden with large eggs. This naturally indicates that in spite of the critical nature of the abnormality, the dog-fish did not, as one would expect, suffer starvation and death, but continued to feed and was able to maintain its normal physiological balance. The true gullet of the dog-fish, as also of the abnormal trout, is, as a result of eversion and prolapsus, transformed into an inverted pocket in the buccal cavity. Passage of food through it is, therefore, a mechanical impossibility. The small 'slit-like aperture' or the invaginated groove towards the anterior end of the sac is the only passage or a sort of 'pseudo'-gullet that leads into the distal loop of the stomach. Ingestion of food through a groove of this nature seems improbable, but solution of the problem must await further research on similar abnormal specimens.

The specimen under report is preserved in the collection of the Zoological Survey of India, Indian Museum, Calcutta.

2. On a specimen of *Silurus cochinchinensis* Cuv and Val., showing eversion of stomach into the pharyngeal cavity.

By K. Krishnan Nair.

In a small collection of fish made by Mr. V. P. Sondhi, Geological Survey of India, from the Southern Shan States, Burma. Dr. S. L. Hora found a specimen of *Silurus cochinchinensis* Cuvier and Valenciennes with a large tumour-like growth in the mouth. As Mr. D. D. Mukherji had recently studied a similar abnormality in a Brown Trout (*Salmo fario* Linn.), the specimen was given to him for a detailed report. On Mr. Mukherji's death Dr. Hora very kindly handed over the specimen to me for study.

I take this opportunity of recording my grateful thanks to Dr. Baini Prashad, Director, Zoological Survey of India, for affording me facilities for work and my great indebtedness to Dr. Hora for giving me an opportunity to report on such a rare abnormality and for his valuable suggestions.

The specimen under report is 191 mm. in total length and in general appearance seems to be quite healthy. The abnormality was noticed on account of its mouth being widely open through which a massive thumb-shaped structure could be seen. The structure extended right up to the jaws (Fig. 4, *ap.*) so that the mouth could not be closed even with some effort. When, however, the pharynx was cut open from the

side, the sac-like structure was fully exposed (Fig 5) It was found to be broadly rounded and closed at the anterior end and

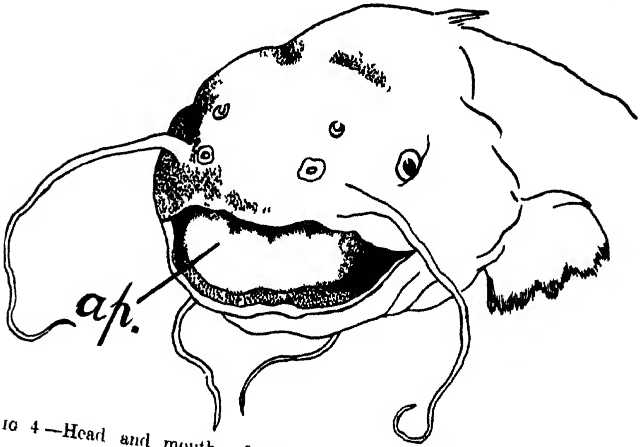

FIG 4—Head and mouth of the abnormal *Silurus cochinchinensis* Cuv and Val, to show the position of the sac formed by the eversion of the stomach × 2
ap, abnormal pouch formed by the eversion of the stomach lying in the mouth

slightly tapering posteriorly where it terminated into a wide circular opening (Fig 5 *po*) It was 25 mm long 14 mm

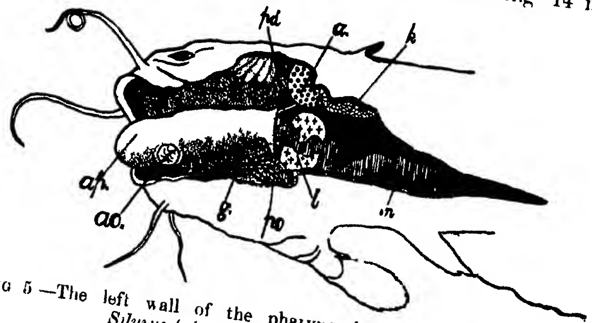

FIG 5—The left wall of the pharyngeal cavity of the abnormal *Silurus* fish cut open laterally to show the structure and position of the sac Same size
a, air bladder *ao*, anterior opening of the sac, protected by sphincter like muscles, *ap*, abnormal pouch formed by the eversion of the stomach, *g*, gills, *m*, intestine, *k*, kidney; *l*, liver, *pd*, pneumatic duct, *po*, posterior opening of the sac

broad, and 8 mm. deep. On a closer examination another small opening (Fig. 5, *ao.*) with sphincter-like muscles, was found on the left hand side of the sac at some distance from its anterior blind end. The intestine came out of the posterior opening of the sac behind which the liver (Fig. 5, *l.*) was also situated.

On opening the sac from the side, duodenum, spleen, fat bodies, gall-bladder (Fig. 6, *gb.*) and a considerable length of

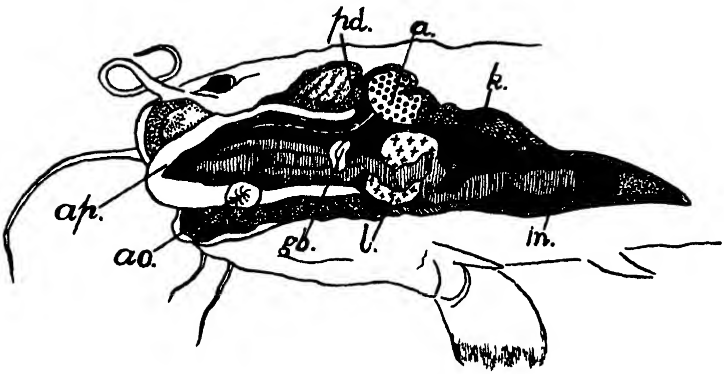

FIG. 6.—The sac formed by the eversion of the stomach cut open laterally through its left wall to show the disposition of structures within it *in situ*. Same size.
a., air-bladder; *ao.*, anterior opening of the pouch; *ap.*, abnormal pouch; *gb.*, gall-bladder, *in.*, intestine; *k.*, kidney; *l.*, liver; *pd.*, pneumatic duct.

the intestine were found lying inside the sac. The duodenum commenced from the small aperture already noticed on the outer side of the sac, and along with the intestine formed two incomplete loops inside the cavity of the sac. The pneumatic duct (Fig. 6, *pd.*) which connects the oesophagus with the air-bladder, was also found inside the sac of the abnormal specimen.

The abnormal positions of the various organs referred to above are similar to those described by Mudge [1] in a Dog-fish and by Mukerji in a Trout, and these have undoubtedly resulted from the eversion of the stomach into the cavity of the mouth. Mudge, from a detailed study of the vascular system, had concluded that the abnormality was of a permanent nature, whereas Mukerji, who had a poorly preserved specimen and could not, therefore, study the vascular system, did not come to any definite conclusion on this point. It was, however, indicated by him that a fish possessing such an abnormality could not

[1] Mudge, Geo. P.—*Proc. Zool. Soc. London*, II, p. 490 (1905); *Zool. Anz.*, XXX, pp. 278–280, 1 fig. (1906).

feed properly. The abnormal specimen of *Silurus* is also in a poor state of preservation so that the details of its vascular system could not be studied. From the nature of the structures described above I am also of the opinion that it is impossible for the fish to catch any prey or to ingest any kind of food, especially on account of the massive bag-like structure in the mouth which practically fills the whole of the cavity.

Dr. Hora (*vide* Mukerji) has already expressed an opinion that an abnormality of this nature is caused by a sudden eversion of the stomach which would cause the death of the fish through asphyxiation. This view seems more probable, for all the abnormal specimens of this nature known so far, have been found to be quite healthy in all other respects.

[Early in May, 1937, Dr. H. S. Rao of the Zoological Survey of India kept under shade in a rectangular glass aquarium of 5 gallons capacity about half a dozen young specimens of live *Glossogobius giuris* (Ham.), which had been taken from the Intake Chamber of one of the filter-beds at the Pulta Waterworks, Calcutta. A few living specimens of *Viviparus bengalensis* had already been in the aquarium since the previous day. A couple of hours after the introduction of the fish, he noticed the presence of a fragment of a partially digested fish at the bottom. A few minutes later a second fragment consisting of the head portion of a fish was found, and on keeping a close watch he observed one of the *Glossogobius* opening its mouth widely to thrust out the partially digested remains of another fish. At the end of 3 hours he found 5 such fragments, which he removed from the aquarium. After about 6 hours all the fish were found dead.

The above observation shows that under certain unhealthy conditions the fish are capable of ejecting through the mouth the contents of the stomach. It is quite possible that sometimes this action may be so violent that the stomach may become everted into the cavity of the mouth. The abnormalities reported above by Mr. D. D. Mukerji and Mr. K. K. Nair are, in my opinion, the result of the same or some other similar action of the stomach.—*S. L. HORA*.]

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ARTICLE NO. 7.

On earthworm populations and the formation of castings in Rangoon, Burma.

BY MAUNG HLA KYAW *and* G. E. GATES.

The observations presented herewith were made on the Judson College compound in the Kokine quarter of Rangoon during the rainy season of 1935.

Two sample plots, each exactly ten feet square, about fifty feet apart, were marked off on an unshaded lawn. The soil in these plots is rather poor, all of the top soil have been removed in grading operations five years previously. The soil is lateritic, formed *in situ* from alluvial material under conditions of continuous high temperature and marked seasonality of rainfall, the silica and bases having been leached out leaving in the upper layer iron and alumina. The plots were covered by a coarse grass.

On the 25th of July all castings were carefully removed from the plots and discarded. From the western plot 56 *Eutyphoeus foveatus* castings were removed, nearly all of which were open. From the eastern plot 37 *E. foveatus* castings were removed. Some of these castings had been closed at the top or plugged throughout. For twenty days the castings were collected at irregular intervals during the daytime and allowed to dry out in the laboratory. Then, after the next heavy shower (so that the ground might be thoroughly soaked), a vermicide was applied to each plot. As the worms emerged they were collected, preserved and later identified. The worms first to appear, almost as soon as the vermicide was applied, were *E. foveatus.*

Experimentation previously with vermicides had shown that when the ground is thoroughly soaked prior to application of the chemicals practically all of the worms are stimulated to come out onto the surface. At least digging, after application of the vermicides, has failed to turn up additional specimens. It is of course possible that some worms near the borders of the plots, having been slightly stimulated by the chemicals, withdraw into the untreated soil where they are able to remain in absence of further stimulation. No worms were seen to emerge on to the surface beyond an inch or two outside the boundaries of the plot. The number of specimens of *E. foveatus* secured from each plot agrees roughly with the number of open castings secured from the plot at the beginning of the period. In these circumstances it is probable that all of the larger species of worms .from both plots were collected. Specimens of small size, similar to that of *Dichogaster bolaui* or even smaller, may

have been concealed from view by the matted leaf blades and stalks of grass, and hence lost.

Earthworm Populations.

From the first plot, that towards the west, 238 worms belonging to at least six species were collected.

Species.	Number of specimens.
Drawida sp	1 juvenile
Drawida rara	1 aclitellate
Pheretima planata	62 aclitellate
Pheretima campanulata	27 aclitellate
Octochætoides birmanicus	11 clitellate
Eutyphoeus foveatus	50 clitellate
Dichogaster bolaui	22 aclitellate
	45 clitellate
Dichogaster sp.	19 juveniles
Total	238

From the second plot, that towards the east, 168 worms belonging to at least six species were collected.

Species.	Number of specimens.
Megascolex mauritii	51 juvenile
	16 aclitellate
	30 clitellate
Octochætoides birmanicus	11 clitellate
Eutyphoeus foveatus	23 clitellate
Eutyphoeus sp.	1 juvenile
Dichogaster bolaui	24 clitellate
Dichogaster sp.	11 juvenile
Pontoscolex corethrurus	1 juvenile
Total	168

Estimates of earthworm populations per acre, on the basis of the number of individuals in the sample plots are 103,672 and 73,180; the average of the two estimates 88,426. These estimates may be compared with Hensen's figures for the Lumbricidæ (as quoted by Darwin, 1881, p. 159 [1]) of 53.767 per acre.

Stephenson (1930, p. 627) believes that this figure is very small. However, it should be noted in connection with the Burmese estimates, that a number of the Rangoon species are fairly large, and that none, excepting only *D. bolaui*, are really small. Thus strongly contracted, preserved specimens are frequently as large as indicated below.

[1] The page numbers are the same in the English and American editions.

Species.	Length.	Diameter.
E. foveatus	250 mm.	10 mm.
M. mauritii	210 ,,	5 ,,
O. birmanicus	140 ,,	6 ,,
P. planata	170 ,,	7 ,,
P. campanulata	200 ,,	7 ,,
P. corethrurus	120 ,,	6 ,,
D. rara	80 ,,	3 ,,
D. bolaui	40 ,,	2 ,,

Furthermore, a very considerable proportion of the worms obtained from the plots are full grown or nearly full grown though not necessarily clitellate while practically all of the juveniles were sufficiently developed to enable specific identification. Juvenile specimens of *M. mauritii* from the east plot are 30–50 mm. long and 3-3½ mm. in diameter. Very young individuals if or when present might be expected to increase the numbers considerably.

Castings.

Two types of castings were collected from the sample plots during the twenty day period. One of these types, frequently referred to as tower-like is formed by *Eutyphoeus foveatus*. Castings of the second type are deposited in the form of piles of fæcal strings more or less completely constricted transversely to form nearly spheroidal pellets. Castings of this type may possibly be formed at times by *O. birmanicus* though this species has not hitherto formed castings in the laboratory, whereas specimens of *M. mauritii* in the laboratory have formed castings practically identical with those collected on the plot. Furthermore the pellet type of castings was found only on the plot containing *M. mauritii* whereas *O. birmanicus* was present in both plots.

The castings from both plots were allowed to dry in the sunlight in the laboratory during four rainless months of the dry season and were then weighed. The total weight of dried castings from the west plot is 16·5 pounds. All of these castings are of the tower type and were formed by *E. foveatus*. The total weight of the dried castings from the east plot is 11 pounds and 15 ounces of which 11·5 pounds are of the tower type and were formed by *E. foveatus*, 7 ounces of the pellet type formed by *M. mauritii*. Castings were not collected on holidays or Sundays and heavy rains on those days as well as on other days and during the nights certainly washed away numbers of castings for which no estimate is possible. Thus on nine mornings on making the first collection of the day, small remnants of tower-like castings that had been formed and washed away during the night were noted.

In Rangoon the year may be divided into two seasons according to the rainfall; the rainy season comprising the months of May to October and the dry season comprising the months of November to April. The normal rainfall for May is 11·98 inches, for June to September, 15·27 to 21·42 inches per month, for October 6·91 inches. The normal rainfall for November is 2·79 inches, the other months of the dry season practically rainless. Towards the end of the rainy season, the ground begins to dry out as the result of the decrease in rainfall and increase in length of periods of sunshine and the earthworms begin to disappear, presumably retreating deep into the ground from whence they do not return to the surface until the next rainy season is well under way. Hence in monsoon portions of the tropics the formation of castings takes place only during a limited portion of the year. This period varies without doubt from year to year according to the weather. As it was impossible to carry on the observation on casting formation during the whole of the rainy season it is necessary, in order to derive estimates of per annum formation of castings, to use an arbitrary period. This has been set at 100 days. This period does not comprise the whole of the time in which castings are actually deposited. (Casting formation has been noted in June, throughout October and rarely in November.) It should however be noted that in the early and later portions of the rainy season, castings are not formed as often or as commonly as in the remainder of the period. We have further assumed that during the period of 100 days casting formation takes place at the same rate as during the August period of observations. If such an assumption is overconfident, it is at least partially compensated by the failure to secure all of the castings deposited during the twenty day period.

With these qualifications the estimates of the amount of dry earth deposited as castings are: as in the western plot, 16·043 tons per acre (open ground) per annum, all of which is brought up by one species only, *E. foveatus*; as in the eastern plot, 11·606 tons per acre, of which 11·181 tons is brought up by *E. foveatus* and 0·425 tons by *M. mauritii*. The average for the two plots, 13·824 tons per acre, the average for *E. foveatus* alone, 13·62 tons per acre.

These figures are to be compared with Darwin's estimates for the Lumbricidæ; of 7·56 tons per acre per annum on a terrace (Darwin. p. 167), of 16·1 tons on a common (p. 168), and 18·12 tons in a field at the bottom of a valley. The last estimate is possibly too high as the castings were only partially dried but on the other hand is based on a 'working period' of one half year which Darwin regarded as low. *E. foveatus* however in a period of 180 days would deposit 24·5 tons.

Tons and acres are perhaps rather difficult to visualize. More easily comprehended is an estimate based on the sample

plot size. Thus, *E. foveatus*, in a ten foot square plot, in one hundred days will bring up (as in the eastern plot) 57·5 pounds or (as in the western plot) 82·5 pounds. In the western plot each individual (of *E. foveatus*) must have brought to the surface during the twenty days an average dry weight of 0·33 pounds while in the eastern plot each individual must have brought to the surface, on an average, 0·5 pounds, during the same period. For a period of 100 days the averages for individual worms in the two plots are 1·65 and 2·5 pounds, or an average (weighted) per individual for the two plots of 1·917 pounds.

SUMMARY.

Estimates based on two sample plots ten feet square give an average figure of 88,426 earthworms per acre, belonging to eight species. Of these only two (*M. mauritii* and *E. foveatus*) formed castings In one plot *M. mauritii* deposited seven ounces (dry weight) of castings in twenty days. In this same plot 23 specimens of *E. foveatus* deposited 11·5 pounds (dry weight) of castings in twenty days. In the other plot 50 *E. foveatus* deposited 16·5 pounds of castings. Casting formation for a period of one hundred days is estimated at 11·608 tons per acre (open ground), as in one plot or 16·04 tons as in the other plot, or an average of 13·824 tons per acre per annum. One individual *E. foveatus* is estimated (weighted average) to deposit 1·917 pounds (dry weight) of castings per annum.

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Darwin, C.— Earthworms and the formation of vegetable mould. London, 1881 New York, 1882.
Stephenson, J.—The Oligochæta. Oxford, 1930.

ADDENDUM.

During the rainy season of 1936 the Biology department of University College collected castings from a sample plot on the University College compound with the intention of ascertaining whether the problem was such as to justify further investigation. On learning of the previous work the collection of further castings was abandoned but the results already obtained were very kindly handed over by Prof. F. J. Meggitt, head of the department.

The sample plot is only a short distance to the east of the Judson College plots but the elevation is about 20 feet above that of the others though the soil is the same. The plot was marked out by measuring 27 feet in each direction from a four year old tree, *Mangifera indica* Linn. As the tree is now about 10 inches in diameter near the ground, the square marked off is somewhat greater than 18 yards in width though the plot is taken as measuring 54 feet on each side. An area nearly 16

feet in diameter is directly under the foliage of this tree while a circular area with a diameter of about 17 feet is shaded.

On July 28 all castings were removed from the plot and discarded. On the 29th and each day thereafter until and including the 19th of August, except on Sundays, the castings were collected at some time between noon and two o'clock. On days of heavy rainfall, ' over half the castings were in such a condition that they could not be collected '. In a circular area extending 6 feet on all sides from the tree trunk no castings were found. External to this central area there is a circular belt about 1½ feet wide under the foliage of the tree in which but few castings were found. Beyond this belt is another belt, about six inches wide and within the shade of the tree in which castings were more numerous though not as frequent as within the unshaded portion of the square. The castings collected are all tower-like and were formed by *E. foveatus*. No pellet-like castings were noticed.

The castings were allowed to dry in the laboratory until December 22 and were then weighed, the total weight of the castings from the sample plot, 73·75 pounds. For a period of 100 days it is estimated that in conditions similar to the sample plot 2,078 pounds per acre of dry earth would be deposited in the form of castings.

On the Judson College compound, near Prome Road, is a grove of trees with such dense shade that the ground is bare or almost bare throughout the rains. This area was under observation during the rainy season of 1936 and during that season no *E. foveatus* castings were found on the densely shaded bare ground, though *E. peguanus* castings were common and tower-like castings of certain species of *Pheretima* were occasionally found. Towards the edge of the grove on ground where grass was growing, *E. foveatus* castings were occasionally found. On other parts of the college compound *E. foveatus* castings have not been found, or have been found only rarely, on ground directly under trees, *i.e.*, under the foliage, even though the lowest branches may be some distance from the ground.

On open ground with thick cover of grass intermingled with much sensitive plant (waste land) in the vicinity of the college, the foveatus castings are often very closely crowded, apparently as closely as on the Judson College sample plots.

Judson College,
Rangoon.

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ARTICLE NO. 8.

Common Diatoms of the Loktak Lake, Manipur, Assam.

By KALIPADA BISWAS.

Contributions towards the knowledge of the Diatom flora of the Indian Empire are rather scarce. Since the publication of Dr. Nellie Carter's 'Freshwater Algæ from India', in the Records of the Botanical Survey of India, vol. IX, No. 4, 1926, and the writer's 'Census of Indian Algæ—Scope of Algological Studies in India', published in the Revue Algologique, Tom VI, Fas. 2, 1932, no systematic attempt has been made towards revealing the enormous Diatom flora of the vast country.[1] Mr. Majid of the Punjab University notes forty-two species from the Punjab in his paper entitled 'A short note on the occurrence and the distribution of Diatoms in the Punjab', published in the Journal and Proceedings of the Asiatic Society of Bengal (new series), vol. xxix, No. 4, 1933. But the nomenclature he uses indicates that he has been working under the difficulty of not having sufficient literature. Such a difficulty confronts many a Diatom enthusiast in this country and the writer himself was not less handicapped for want of sufficient literature and type slides.

During the last twelve years I have managed to procure fairly exhaustive literature, and added these to the rare old standard works on this branch of algology preserved in the library of the Royal Botanic Garden, Calcutta. The writer is also in possession of the valuable microscopic slides of the authentic species representing most of the genera of these silicified members of Algæ. These rare slides have been received from my revered teacher, the late Professor Paul Brühl, who purchased this collection from one of the German Diatom specialists. The writer acknowledges his deep debt of gratitude to his teacher by this paper. In the study of Diatoms two main difficulties are generally experienced—namely accurate determination of the specimens and the correct nomenclature to be adopted. Accurate identification of Diatoms depends upon sufficient material, upon detailed examination of as many forms as are available, both empty as well as living frustules, upon accurate detailed measurements and camera lucida drawings of the different views. It is necessary also to observe the number of markings, and to make comparison with authentic specimens. Some of the well known books such as Oltmann, Karsten, Fritsch, Smith,

[1] My account of the two interesting species of Diatoms in my paper on 'the Association of Algæ and Animals' published in the Hedwigia, Heft 3, B and 76, 1935 is the last reference to this fascinating group of unicellular plants.

are useful for generic diagnosis. But a Diatomist must not fail to consult Kuetzing's Phycologicæ Algarum (Diatomaceæ) and the detailed specific descriptions in De-Toni's Sylloge Algarum, Bacillarieæ, Sect. 1–111, 1891–1894; Van Heurck's Synopsis des Diatomeés de Belgique including his Atlas, 1880-1881; Wolle's Diatoms of the U.S.A.; Smith's British Diatomaceæ, vols. 1–11, 1853–1856; Schönfeldt and Hustedt's Contributions to Diatom flora in Pascher's Susswasser flora, Deutschlands, Osterreichs und der Schweiz; Hustedt's book in Silicophyta. As regards nomenclature this has become simplified by the publication of the recent outstanding works of Mill's Index to the names of Diatoms—a work indispensable to every Diatomist. To an Indian worker the lists appended to my paper on Bacillariophyta—reporting the previously recorded species together with the literature and a list of species which are likely to occur in India, might prove useful.

The specimens dealt with in this paper are found mixed with other Algæ collected by Dr. S. L. Hora and the late Dr. N. Annandale, F.R.S., from the Loktak Lake, Manipur in 1920. The geographical and physiographical features of the Loktak Lake are discussed in the Monograph 'Algæ of the Loktak Lake', written in collaboration with the late Professor Paul Brühl, and published in the Memoirs of the then Asiatic Society of Bengal—now Royal Asiatic Society of Bengal, vol. viii, No. 5, pp. 257–316, with 22 plates and 170 figures, 1926. The specimens were preserved in spirits of wine for three years and subsequently transferred to 5% Formalin Alcohol (i.e. 5 c.c. of commercial Formalin and 95 c.c. Alcohol). This transference hardly improved their condition. The inner contents were nearly all destroyed as the figures illustrate. But empty shells were quite clear and this aided their determination. The type of vegetation in the Loktak Lake is particularly suitable for harbouring a Diatom flora and unicellular and colonial members of Hydro-dictyaceæ. Although the Desmid flora was exceptionally rich, Diatom species seem to be far fewer than would be expected in such a place. The congestion of vegetation, leading to the physico-chemical condition of the water, prevented many free living and free floating species of Diatoms from flourishing. The abundance of Gomphonema species and other stalked and epiphytic species are of common occurrence in such areas. The fauna of the lake—particularly fishes and crustacea—is subservient to the particular type of aquatic Phanerogams and Cryptogams predominant. Also when the writer visited the lake in 1930 species of Synendra and Gomphonema appeared to be dominant. But further scrutiny of my collection provides a few more species to those already studied.

Both the Diatom flora as well as the Desmid flora of this region has some importance from the standpoint of distribution as the outlying district of Assam is close to Upper Burma.

Whether the Algal flora of this part of the country represents more of an Assamese element or a Burmese element—is a point which cannot be settled owing to our present imperfect knowledge of the algal flora of these two regions. But from the data so far available it can be stated that the algal flora, not unlike those of Phanerogams, is—in general—Malayan.

In systematic enumeration of the species short description has been added to each mentioned. Such a description has been supplemented wherever necessary with notes on nomenclature, particularly in cases of those specific names which demand clarification.

I express my sincere thanks to Sir William Wright Smith, Regius Keeper, Royal Botanic Garden, Edinburgh, for his kindly placing at my disposal all the available literature and thus enabling me to scrutinize the results of my study of these Diatoms. I am also indebted to Mr. R. Ross, Diatomist, British Museum (Natural History), London, for his co-operation in checking my determination with reference to the type slides.

Diagnosis of the Species.

1. **Synedra ulna** (Nitzsch) Ehrnberg.

Frustules occurring in small fascicles or solitary mixed with other algæ, attached to submerged waterplants, or free-floating, very variable in dimensions, 150 to 450μ long, linear lanceolate, truncate, somewhat rostrate at both ends in girdle view, obtusely rounded in valve view. striations distinct, 9-10 in 10μ.

Hab. Loktak Lake, Manipur, collected by N. Annandale and S. L. Hora, 1920, very common.

2. **Synedra affinis** Kutz. var. *fasciculata* (Kuetzing) v. Heurck.

Frustules occurring in fascicles, rarely solitary mixed with other algæ, attached to submerged plants or free floating, sometimes forming predominating species of plankton flora, valve view small lanceolate, narrowly fusiform, rounded or slightly thickened at both ends, obtuse or acute at the apices, girdle view linear, 37μ long, broad at the middle, 3μ wide at the apices, 20–25 striations in 10μ.

Hab. Loktak Lake, Manipur, collected by N. Annandale and S. L. Hora, 1920, common.

The Loktak form is more obtuse at the apices and its systematic position is intermediate between the var. *fasciculata* and the var. *obtusa*. It approaches in shape more to var. *obtusa* as figured in Arnott's manuscript and printed in Synopsis des Diatomeés de Belgique Par la Dr. Henri Van Heurck, Atlas Pl. XLI, fig. 12, (1880-1881).

3. **Eunotia lunaris** (Ehrenberg) Grunow.

Frustules long, arcuate, narrow in valve view, somewhat rostrate-capitate at both ends, in girdle view narrowly rectangular with truncate apices, 20 to 150μ long, 3-4μ broad, 14–17 striations in 10μ.

Hab. Loktak Lake, Manipur, collected by N. Annandale and S. L. Hora, 1920, not very common.

The species is nearly always at first epiphytic, afterwards when dislodged—it is free-floating. Owing to its epiphytic nature being dominant Van Heurck puts this species in his key under the section 'an frustules parasites sur d' autres plantes'. Schönfeldt in Pascher's Süsswassr flora (Bacillariales). Heft 10, 1913, accepts Grunow's new combination *Pseudoeunotia lunaris* (Ehrenberg) Grunow, and places this species under the subgenus Pseudo-eunotia retaining however the original name *Eunotia lunaris* Ehrenberg. De Toni in his Sylloge Algarum, vol. 11, 1891, follows Grunow's nomenclature and describes this species under the name *Pseudo-eunotia lunaris* (Ehr.) Grun. The oldest name is *Synedra lunaris* Ehrenberg Abh. Berb. Akad. 1831. Grunow subsequently transferred the genus rightly to *Eunotia*. Van Heurck is therefore justified in adopting the combination—*Eunotia lunaris* (Ehrenberg) Grunow—which is consistent with the rules of nomenclature. The writer maintains Van Heurck's combination. Karsten in Engler's Die Natürlichen Pflanzenfamilien, Band 2, Bacillariophyta 1928, does not seem to accept Grunow's view. Karsten reduces this genus *Pseudo-eunotia* to *Amphicampa* Ehrenberg. F. W. Mills in 'An Index to the genera and species of the Diatomaceæ', p. 687, 1934, also adopts the combination *Eunotia lunaris* (Ehn.) Grun.

4. **Mastogloia Meleagris** (Kuetzing) Grunow.

Frustules lanceolate, elliptic, gradually attenuated towards sub-obtuse or obtuse apices, imperceptively constricted at the poles, 36 to 57μ long, 12 to 15μ broad at the middle, 6μ broad at the apices, 10 striations in 10μ.

Hab. Loktak Lake, Manipur, collected by N. Annandale and S. L. Hora, not common.

The occurrence of this species in fresh-water lake is rather unusual. It is noteworthy to record this species from a lake like that of the Loktak lake, for the first time from India. Leuduger-Fortmorel reported its occurrence in the island of Ceylon. The lesser number of striations observed in the Loktak form may be due to physico-chemical nature of the water of the lake.

5. **Gomphonema constrictum** Ehrenberg.

Frustules in valve view cuneate, inflated at the middle, rounded at the upper end, obtuse at the lower, more or less

constricted towards the upper extremity, attenuated below, 4μ broad at the narrow base; girdle view conical, obtuse at the base, gradually uniformly wider at the apices, mucilage stalks long, 3μ wide, hyaline, dichotomously branched, often bearing at the apex a pair of frustules, 45μ long, 15–18μ broad.

Hab. Loktak Lake, Manipur, collected by N. Annandale and S. L. Hora, 1920, very common—attached to submerged plants.

6. **Gomphonema acuminatum** Ehrenberg, var. *elongata* W. Smith.

Frustules in valve view elongate, cuneate, gradually attenuated below, slightly swollen at the middle, not constricted towards the upper extremity, somewhat apiculate above, girdle view cuneate, constriction obovate, 90μ long, 18μ broad, 9-10 striations in 10μ.

Hab. Loktak Lake, Manipur, collected by N. Annandale and S. L. Hora, 1920, rather common.

7. **Gomphonema olivaceum** (Lyngbye) Kuetzing.

Frustules lanceolate, attenuated at both ends, apex rounded, base acute, 2-3μ wide, girdle view cuneate, 36 to 45μ long, 3–9μ broad, 10–15 striations in 10μ.

Hab. Loktak Lake, Manipur, collected by N. Annandale and S. L. Hora, not very common.

8. **Epithema Zebra** (Ehrenberg) Kuetzing.

Frustule in valve view arched, attenuated at both the extremities, obtusely rounded at both ends; girdle view rectangular, truncate at the apices, 39 to 51μ long, 9 to 15μ broad, 4 rather robust striations in 12μ.

Hab. Loktak Lake, Manipur, collected by N. Annandale and S. L. Hora, not common.

9. **Rhopalodia gibba** (Ehrenberg) O. Müller.

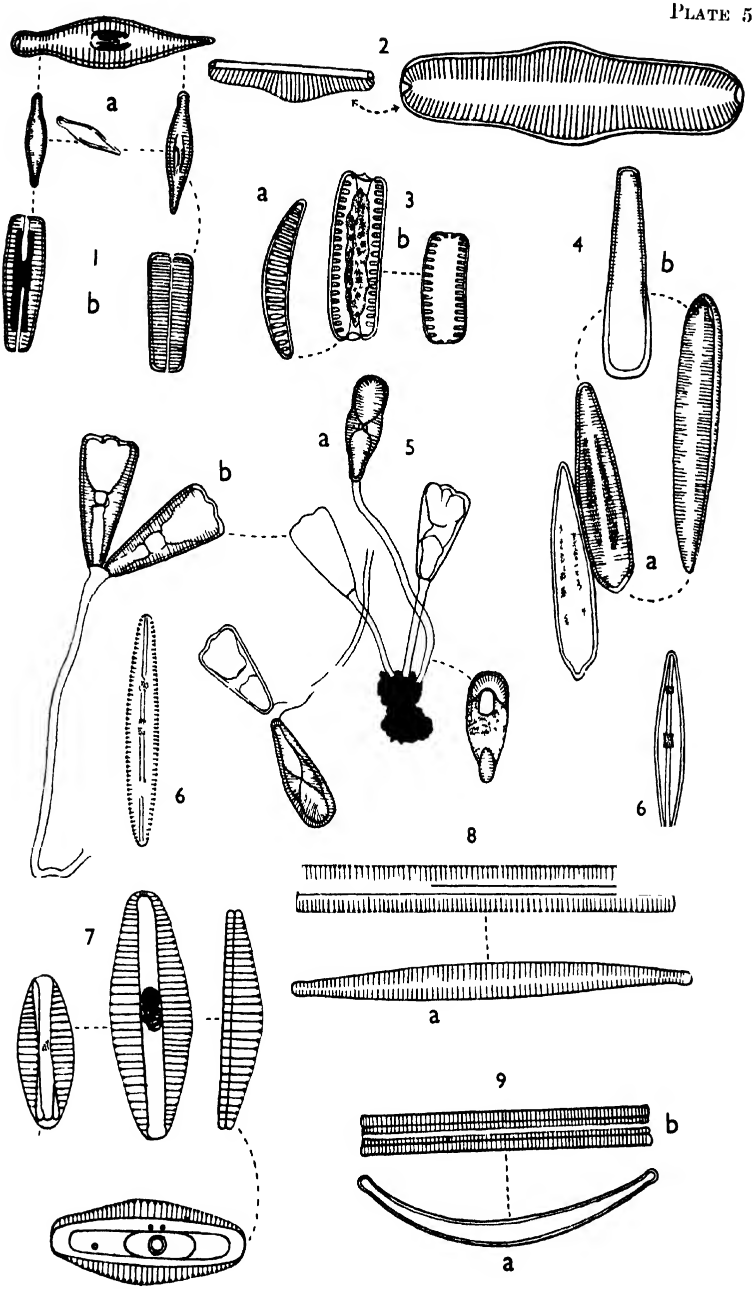
Frustule in valve view linear, slightly inflated at the middle, rounded at both ends; girdle view linear obtuse, 70 to 80μ long, 20–24μ broad, 15μ wide at both extremities, markings robust, 12 to 15 in 10μ.

Hab. Loktak Lake, Manipur, collected by N. Annandale and S. L. Hora, not common.

Royal Botanic Garden, Edinburgh.
23rd November, 1936.

EXPLANATION TO PLATE 5.

FIG. 1.—Gomphonema olivaceum : (*a*) valve view, (*b*) girdle view × 900.
„ 2.—Rhopalodia gibba, valve view × 600.
„ 3.—Epithemia Zebra : (*a*) valve view, (*b*) girdle view × 500.
„ 4.—Gomphonema acuminatum var. elongata : (*a*) valve view, (*b*) girdle view × 350.
„ 5.—Gomphonema constrictum : (*a*) valve view, (*b*) girdle view × 350.
„ 6.—Synedra affinis var. fasciculata × 800.
„ 7.—Mastogloia Meleagris × 225.
„ 8.—Synedra ulna : (*a*) valve view, (*b*) girdle view × 500.
„ 9.—Ennotia lunaris : (*a*) valve view, (*b*) girdle view × 600.



DRAWN BY K. BISWAS.

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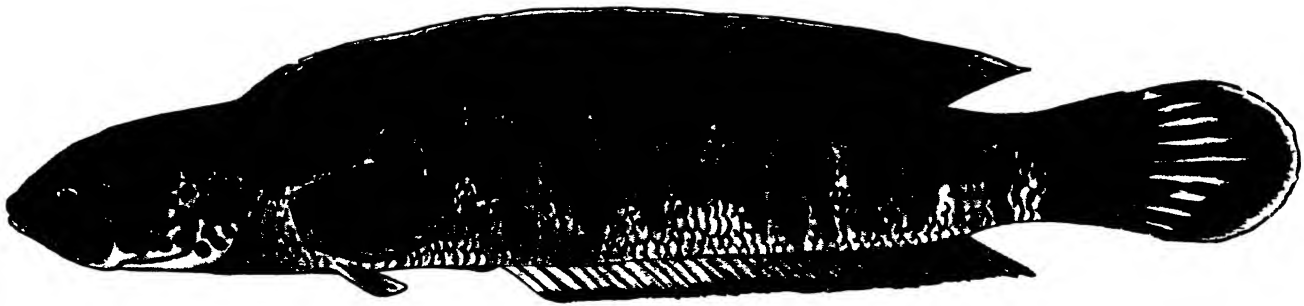


Ophiocephalus amphibius McClell
THE BORA CHENG

Journal Royal Asiatic Society of Bengal. Science.

Volume III, 1937.

ARTICLE No. 1.

The Fishes of Northern Bengal.

By G. E. SHAW *and* E. O. SHEBBEARE.

CONTENTS.

INTRODUCTION.

At intervals during the last fifteen years, 1918 to 1933, we have been collecting the fish of the rivers, streams and ponds in the hills and plains of the Darjeeling District and the adjoining Duars. Having found many more species than were previously known in this area, we have made a list of them and now publish it with notes and keys that may help others to identify them.

Broadly our area extends over the whole of the Darjeeling and Jalpaiguri civil districts, though we have not thoroughly explored the tanks of the southern part nor the highest of the hill-streams. We have included in our list species that we have only found on sale in bazaars, but these we have shown in brackets as many of them are brought by rail and may not occur naturally in the district. We have also included a few fish which we have not ourselves found in the area but which have been reliably recorded from it. We discovered only one new species which we named *Glyptothorax horai* after Dr. Hora, and the account of which was published in the Journal of the Bombay Natural History Society (vol. XXXIX, p. 188, 1937).

Names have been checked in all cases by reference to specimens in the Indian Museum and we have to express our

gratitude to the staff of the Zoological Survey, especially to Dr. S. L. Hora, and his assistant, the late Mr. Dev Dev Mukerji, for the help they have given us. We have also to thank the staff of the Fish Section of the British Museum of Natural History for permission to examine their collection and especially Mr. J. R. Norman who has helped us with his advice.

Books consulted have been Day's 'Fishes of India', Day's volumes on fishes in the 'Fauna of British India' series, 'Records of the Indian Museum' and 'Journal of the Asiatic Society of Bengal.'

The fin-formulæ and abbreviations used are Day's and are explained on p. 3. In accordance with the British Museum usage we have called the hinder paired fins 'pelvics' and have substituted this word for 'ventrals' in our quotations from Day, but we have retained the abbreviation 'V' for these fins in the formulæ. The only symbol not used by Day that we have introduced are brackets enclosing the scientific names of those species which we have only obtained in bazaars and may not be indigenous to our area.

The text figures are reproductions from Day's 'Fishes of India', 'Records of the Indian Museum', and 'Journal of Asiatic Society of Bengal'; a few are from our own sketches. We have made use of the best representation known to us of each species. The photographs are our own.

The area is a particularly interesting one. A Bengali proverb says 'Where water, there fish' and, as in all warm, wet countries, there is little water that does not hold them. Himalayan torrents, the large rivers, clear, gravelly jungle streams and muddy ponds each have their own fish populations adapting themselves to varied conditions. A hill stream, often only a few isolated rock-basins in the dry season, is one continuous cataract in the rains, and fish must flatten themselves and stick to the bottom as best they can, or be swept away. Many have adapted themselves beautifully to this end. In the darkness of muddy water feelers are better than eyes and many, the Cat-fishes in particular, have turned this to their advantage.

The borrow-pits, from which earth is dug to raise the level of roads, look unlikely enough spots for aquatic life in March, when whatever caked mud may remain at the bottom is covered in powdery wayside dust; nevertheless, within a few days of the burst of the monsoon, they teem with tiny fish, newly hatched offspring, no doubt, of parents that were scooped out by hordes of muddy children as the pits dried up four or five months earlier. One might expect only mud-dwellers to inhabit these borrow-pits but the majority of the fish in them are beautiful, even gorgeous, members of such silvery genera as *Barbus*, *Barilius* and *Danio*.

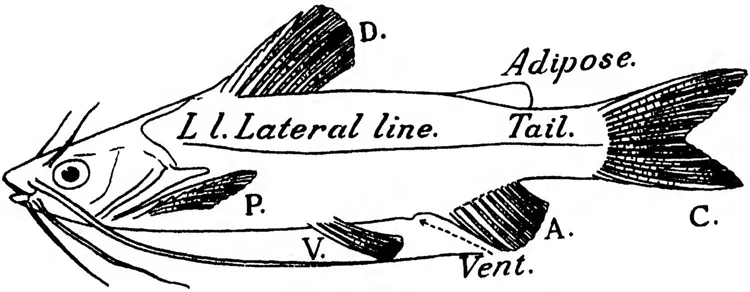
Our collection has been divided between the Indian Museum, Calcutta and the Darjeeling Natural History Museum.

Explanation of Principal Terms and Abbreviations used in the Text.

D = Dorsal (fin), ' fin ' omitted when the meaning is clear.
P = Pectorals } ' Paired ' fins, homologous with the fore
V = Pelvics (or Ventrals) } and hind limbs of other vertebrates.
A = Anal
C = Caudal—in common parlance the ' tail ', a term here reserved for the part of the body between the vent and the base of Caudal.

The Adipose dorsal or Adipose fin has no rays. It is present in many of the Cat-fishes (also in trout and salmon).

Formulæ for fins :—Figures refer to the number of rays. Two figures separated by a hyphen (-) denote the limits between which the number may vary. An oblique stroke (/) separates two types of rays in one fin, such as undivided or entire from divided or branched rays. A vertical stroke (|) separates



Text-fig. 1.—Lateral view of a Siluroid fish, *Mystus vittatus* (Bloch) labelled to show certain parts of body.

different fins, such as the Dorsal from the Adipose dorsal in Cat-fishes, or the Spiny from the Articulated Dorsal in Perches.

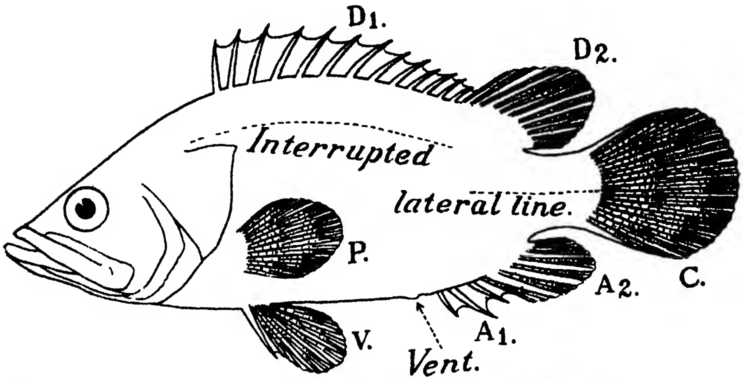
The formula for the Dorsals in the upper figure would be :— D 2/7 | 0, *i.e.*, 2 undivided and 7 branched rays in the Dorsal; the ' 0 ' representing the rayless Adipose dorsal.

The formula for the Dorsals in text-figure 2 would be :— D 13 | 11, *i.e.*, 13 rays in the Spiny and 11 in the Articulated Dorsal.

The Lateral Line (L.l.) is a row of perforated scales running from the angle of the gill-opening to the base of the Caudal in most scaled fishes. It may be absent, incomplete or interrupted.

Scales :—These are ordinarily counted along the lateral line, where there is one, the number being shown by a figure following the letters L. l. Where there is no lateral line they are counted along the lateral row of the scales where the lateral line would ordinarily be and shown after the letters L.r. Another count that is sometimes made is the number of transverse rows

of scales between back and belly. It is counted from the base of the Dorsal to the lateral line and again from the lateral line



TEXT-FIG. 2.—Lateral view of a scaly fish, *Nandus nandus* (Hamilton), labelled to show certain parts of body.

to the point of insertion of the Pelvics. The number is shown after the letters L. tr.

The L. 1. (or L. r.) figures are an indication of the comparative size of the scales and a comparison between this figure and the L. tr. count gives an idea of the depth of the body.

Barbels :—These are named after the part from which they spring :—*Nasal* from the region of the nostrils, *Rostral* from the snout, *Maxillary* from the upper jaw and *Mandibular* from the lower jaw.

LIST OF FISHES.

The general classification of fishes adopted in the list is that proposed by Dr. C. Tate Regan, F.R.S., in his article on 'Fishes' in the Fourteenth Edition of the *Encyclopædia Britannica* (1929). The genera under their respective families and the species under each genus are alphabetically arranged. Page references to the descriptions of the species are also given.

Page

Class : **PISCES.**

Sub-class : NEOPTERYGII.

Order : ISOSPONDYLI.

Sub-order : *CLUPEOIDEA.*

Family : **Clupeidæ.**

1. *Gadusia chapra* (Ham.) 12
2. *Hilsa ilisha* (Ham.) 13

Family : **Dorosomidæ.**

3. *Gonialosa manminna* (Ham.) 14

Identification Table for Principal Groups.

The list on pp. 4–8 shows the Order, Sub-order, Family, Sub-family, and Genus to which each species belongs. This gives the true scientific relationship of one to another. For the keys, however, we have taken as our units groups of genera of any denomination that suited our purpose; thus the CAT-FISHES correspond to a sub-order, whereas the MURRELS correspond only to a genus. It was to avoid any confusion that might arise from the unequal status of these 'groups' that we called them by English names. A comparison between the position of the various genera in the list above with their treatment in the groups given below will make this clearer.

The first step in identifying a fish with our keys is to determine to which group it belongs and the key which follows is designed with this object.

A. Fish strikingly abnormal in shape.

Very squat even when deflated; when inflated it becomes a ball with only tail and fins projecting
The GLOBE-FISH, Group XII, p. 124.

Jaws prolonged into a beak ..
The GAR-FISH, Group VIII, p. 108.

Very slender, nearly straight, with the head of a sea-horse
The PIPE-FISH, Group IX, p. 109.

Eel-shaped
Snout long and tapering .. The SPINY EELS, Group XIII, p. 126.
Only one fin (the Dorsal) .. The MUD EEL, Group XIV, p. 128.

***Note.*—We have included the Feather-backs among normally-shaped fishes in spite of their 'tailless' appearance. Some of the Cat-fishes, too, are almost grotesque enough to be called abnormal, but there is no particular feature common to all.**

B. FISH COMPARATIVELY NORMAL IN SHAPE.

(*a*) *Two Rayed Dorsal Fins.*

Scales on body and head (in ***Ambassis*** scales easily rub off)
FISH WITH PERCH-LIKE DORSALS, Group X, p. 109.

(*b*) *One Rayed Dorsal Fin.*

An adipose fin behind the rayed dorsal, scaleless
Some CAT-FISHES, Group VII, p. 79.
No adipose fin
Scaleless, barbels at least as long as head, Anal long (29 rays or more)
Remainder of CAT-FISHES, Group VII, p. 79.
Minute scales embedded in skin, longest barbels shorter than head, Anal short (about 7 rays)
The LOACHES, Group VI, key p. 63.
Overlapping scales
Scales on head, which is snake-like, as well as body
The MURRELS, Group XI, key p. 118.
No scales on head
General colour brownish, not metallic
Scales small (L. l. 98–190) and not very evident especially below L. l., base of Anal and vent enclosed in sheath of tile-like scales; rather trout-like
The SNOW-TROUT, Group III, p. 17.
Scales larger (L. l. 35–70)
The CARPS WITHOUT LARGE SWIM-BLADDERS, Group V, p. 60.
General colour metallic
Silvery, abdominal edge sharp and serrated
The HERRINGS, Group I, p. 12.
Silvery, abdominal edge fringed by Anal fin which united with small Caudal to make tail-end taper to a point and fish appear 'tailless'
The FEATHER-BACKS, Group II, p. 15.
Silvery or leaden, abdominal edge rounded or sharp but not serrated
The CARPS, Group IV, key p. 18.

SHORT DESCRIPTIONS OF PRINCIPAL GROUPS.

Group 1. *The HERRINGS*: Corresponding to the family CLUPEIDÆ; 4 genera of one species each included in our list. Probably none of them are found in our area except for sale in bazaars.

Characters:—The whole body, but not the head, covered with overlapping scales; general colour silvery; a single dorsal, no adipose fin and no barbels. The outstanding feature is the sharp and serrated edge of the abdomen.

Group II. *The FEATHER-BACKS*: Corresponding to the family NOTOPTERIDÆ; one genus of which two species are included in our list.

Characters:—The whole body, but not the head, covered with overlapping scales; general colour silvery; a single, very small dorsal, no adipose fin and no barbels. The outstanding feature is the way in which the long Anal, uniting with the small Caudal, makes the tail end taper to a point and the fish appear 'tailless', p. 15.

Group III. *The SNOW-TROUT*: Corresponding to the sub-family SCHIZOTHORACINÆ; 2 genera of one species each are included in our list. They live in hill streams often up to considerable elevations.

Characters:—The whole body, but not the head, covered with overlapping scales but these are small and not very evident especially below the lateral line. Rather trout-like in general appearance. The outstanding feature is a sheath of tile-like scales enclosing the base of the anal and the vent, p. 17.

Group IV. *The CARPS*: Corresponding to the sub-family CYPRININÆ; the largest group in our list, containing 46 species.

Characters:—The whole body, but not the head, covered with well-marked scales, silvery or leaden, often with other colours, usually opaque black or red, or a blue, golden or coppery sheen. Carps have only one Dorsal and no adipose fin; some have barbels, some have not. The abdomen is generally rounded but may come to a cutting edge which, however, is never serrated as in the herrings. A key to the CARPS is on p. 18.

Group V. *The CARPS WITHOUT LARGE SWIM-BLADDERS*: Corresponding to the two families HOMALOPTERIDÆ and PSILORHYNCHIDÆ; our list contains only 3 species.

Characters:—Overlapping scales on the body but not the head; a single Dorsal and no adipose fin, distinguished from the Herrings, Feather-backs, and Carps by being blotched brown in general colour instead of metallic, and from the Snow-trout by the absence of tile-like scales on the anal sheath. Described on pp. 60–62.

Group VI. *The LOACHES*: Corresponding to the family COBITIDÆ; 16 species in this list.

Characters:—Scales rudimentary and embedded in the skin, which generally has a pattern in browns and yellows often a series of dark and light transverse bands. A single Dorsal and no adipose fin. Barbels are short but conspicuous and never longer than the head. The combination of short barbels with absence of an adipose fin serves to distinguish this group from the Cat-fishes, the only group with which it is likely to be confused. A key to the LOACHES is on p. 63.

Group VII. *The CAT-FISHES*: Corresponding to the sub-order SILUROIDEA; an important group in our area, our list contains 34 species.

Characters:—No scales, a single rayed Dorsal and, more often than not, an adipose fin. Barbels are always present and generally they are long. The group contains fishes of all shapes and sizes but bearing an unmistakeable family likeness to one another which is not easily put into words. The presence of barbels longer than the head or an adipose fin or both is, however, a feature that will distinguish them from any other fishes in our area.

There is a key to the CAT-FISHES on p. 79.

Group VIII. *The GAR-FISH*: Corresponding to the family BELONIDÆ; a single species in our area, unmistakeable on account of its long beak, p. 108.

Group IX. *The PIPE-FISH*: Corresponding to the family SYNGNATHIDÆ; a single species in our area like a very slender and straightened sea-horse, p. 109.

Group X. *The FISH WITH PERCH-LIKE DORSALS*: Corresponding to the 3 sub-orders PERCOIDEA, GOBIOIDEA, and ANABANTOIDEA; more than half of all the species of Indian fish have dorsals of this type, but they are typical of salt water rather than fresh and only 11 species are included in this list.

Characters:—The outstanding character is the nature of the Dorsals, of which there are two, the front one having the rays produced beyond the membrane of the fin. The head as well as the body is covered with scales. (*Ambassis* has deciduous scales and frequently appears to be scaleless.) A key to these fishes is given on p. 109.

Group XI. *The MURRELS*: Corresponding to the sub-order OPHICEPHALOIDEA; 6 species in this list, a very distinct group all much alike in shape.

Characters:—Scales on the head, which is snake-like, and the single, very long Dorsal and Anal are sufficient to separate these fishes from all others in our area. Keys on p. 119.

Group XII. *The GLOBE-FISH*: Corresponding to the sub-order TETRAODONTOIDEA; one species in our list, unmistakeable from its shape, squat even when deflated and becoming a ball with only tail and fins projecting when it inflates itself, p. 124.

Group XIII. *The SPINY EELS*: Corresponding to the family MASTACEMBALIDÆ (or RHYNCHOBDELIDÆ); 3 species in this list.

Characters:—Eel-shaped with a long, pointed snout. The Dorsal consists of isolated spines (these may, however, be concealed under the skin in some cases). Described on p. 126.

Group XIV. *The MUD EEL*: Corresponding to the family AMPHIPNOIDÆ; a single species.

Characters :—Snake-like, with a Dorsal but no other fins, living in thick mud, p. 128.

Systematic Description.

Group I.—THE HERRINGS.

All our specimens of this group were from bazaars and it is possible that these fish are not really represented in our area. They are mainly sea-fish which ascend the larger rivers and do not reach the sub-montane streams, though *Gudusia chapra* is also found in tanks.

Characters :—Silvery fish without barbels and generally with a deeply forked Caudal. All the species in this list have the abdominal edge sharp *and serrated*.

KEY.

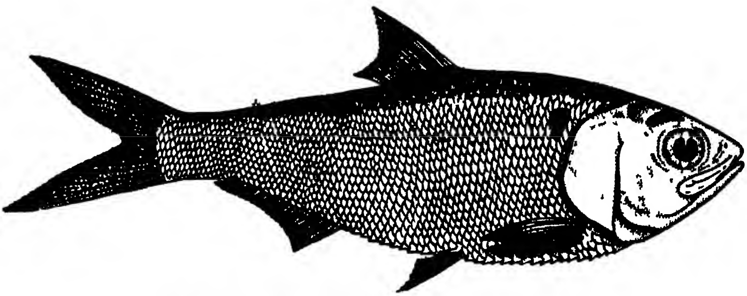
Anal moderate (19–24 rays)—	
L. l. 46–49	*Hilsa ilisha* (p. 13)
L. l. 58–62	*Gonialosa manminna* (p. 14)
L. l. 80–110	*Gudusia chapra* (p. 12)
Anal long (70–80 rays) . .	*Engraulis telara* (p. 14)

[Gadusia chapra (Ham.)], *F.B.I.*, No. 469 *Clupea chapra.*

Bengali : *Khoira* খয়রা ; Hindi : *Suiya* सुइया.

D. 14–16. P. 13. V. 8. A. 21–24. C. 17. L. l. 80–110.

Length of head $4\frac{1}{4}$-$4\frac{1}{2}$, height of body $3\frac{1}{4}$-4 in total length. Somewhat compressed laterally, the abdominal profile sharp and saw-edged, tail deeply forked.



Text-fig. 3.—*Gadusia chapra* (Hamilton).

Colour : Silvery with or without a dark shoulder spot. One of our specimens has four irregular dark marks across the back between the base of the dorsal and the head.

Size: Day says it attains at least 8 inches in length. Our largest was about 6 inches long.

Habitat: Our only specimens have been from Siliguri bazaar. Day gives—'Freshwater rivers and tanks in Sind and throughout India as far south as the Kistna River; absent from the Malabar Coast and Madras'.

[**Hilsa ilisha** (Ham.)], *F.B.I.*, No. 470 *Clupea ilisha*.

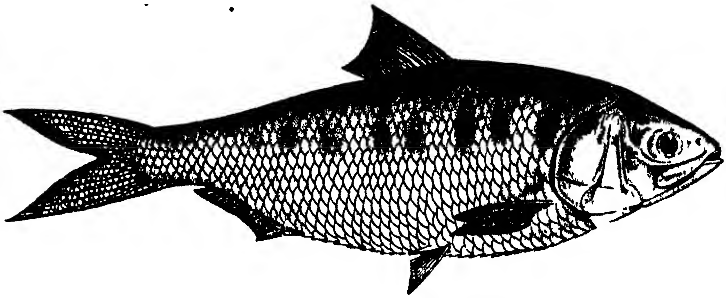
The *Hilsa* (Day also notes another name, the Sable-fish, which we have not heard.)

Bengali: *Ilish* इलिश्; Hindi: *Hilsa* हिलसा.

(*Note*.—Althouth we are aware of no record of this fish from our area, it is so commonly imported and sold here that to omit it from our list might lead to confusion.)

D. 18-19. P. 15. V. 9. A. 19–22. C. 19. L. l. 46–49.

Body laterally compressed, in general appearance not unlike a herring but somewhat deeper (height of body $3\frac{1}{2}$-$3\frac{3}{4}$ in total length.) Caudal deeply forked and partly covered with scales; belly with a saw-edge.



TEXT-FIG. 4.—*Hilsa ilisha* (Hamilton).

Colour: Silvery shot with gold and purple. Young fish have vague, vertical, darker bars across the back and upper part of the sides.

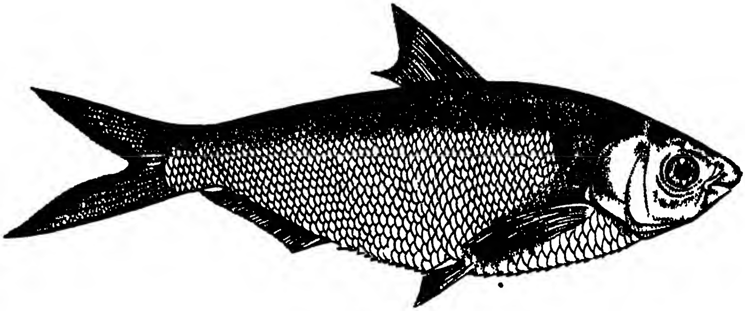
Habitat: *Hilsa* swarm up all the larger rivers of India and Burma to spawn, at the season of the local monsoon. Mature fish are mostly taken in the Ganges from mid May to mid October, when they presumably leave for the sea. We are told that fry, about two inches long, are taken in January and February. These fish mostly reach our districts by rail from Sara Ghat where a fishing fleet operates. Although *Hilsa* go upstream much farther than this (Day records them from Delhi and Hamilton Buchanan from Agra and Cawnpore) we have not heard of them from the Jalpaiguri or Darjeeling districts.

[Gonialosa manminna (Ham.)], *F.B.I.*, No. 489 *Chatoessus manminna.*

Be ıgali : *Khoira* খয়রা.

D. 14-15. P. 15. V. 8. A. 22–24. L. 1. 58–63.

Day gives—' Length of head $4\frac{2}{3}$–5, height of body $3\frac{1}{3}$-$3\frac{3}{4}$ into total length. *Fins*—dorsal commences slightly in advance of the origin of the pelvics, its last ray is slightly prolonged. Caudal deeply forked, lower lobe the longer. *Scales*—irregularly arranged ; scutes (*i.e.* serrations along the belly) strong, 17 between throat ana base of pelvics, and 13 behind it.



TEXT-FIG. 5 —*Gonialosa manminna* (Hamilton).

Colour : Silvery glossed with gold ; cheeks purplish ; back with a bluish-green tint, and usually a black spot on the shoulder. *Fins* yellowish, the dorsal and caudal with dark outer edges.'

Size : Day says it attains at least 11 inches.

Habitat : Day gives—' Fresh waters of Sind, and the districts watered by the Indus and its branches, also the affluents and the main streams of the Ganges, Jumna, Brahmaputra, and Mahanadi.' Our specimen was from Siliguri bazaar.

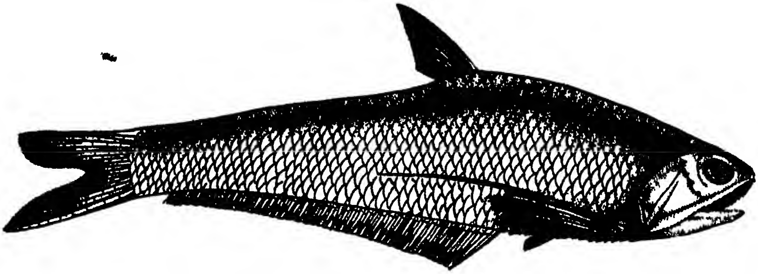
[Engraulis telara (Ham.)], *F.B.I.*, No. 498.

Bengali : *Phansa* ফাঁসা ; Hindi (Bihar) : *Bindi* बिन्दी.

D. 1+14-15. P. 15. V. 7. A. 70–80. C. 19. L. 1. 52.

Day gives—' Length of head 6-7, of body $4\frac{1}{2}$ in total length. *Eyes*—diameter $4\frac{1}{2}$ in length of head, $\frac{3}{4}$ diameter from end of snout, and $1\frac{1}{2}$ apart. The maxilla extends to opposite the gill-opening. *Fins*—origin of dorsal slightly posterior to that of anal, much nearér to snout than to base of caudal fin. Pectoral with its upper ray elongated to opposite centre of anal fin (in some examples this ray is only slightly produced), whilst the fin itself extends to opposite the posterior end of the pelvics ; lower caudal lobe the longer, the upper truncated ; base of the anal fin considerably more than half the total

length without the caudal fin. *Scales*—7 spiny scales before the pelvics and 15 or 16 after them.



TEXT-FIG. 6.—*Engraulis telara* (Hamilton).

Colour: Greenish along back, becoming silvery dashed with gold along the abdomen; dorsal and caudal yellow, the upper lobe of the caudal and the upper margin of the dorsal stained black; pectoral in the young yellowish, but in the adult of a deep blue-black, except the elongated ray, which is usually uncoloured in the posterior three-fourths; pelvics and anal uncoloured.'

Size: Day says it attains at least 16 inches in length. Our specimen was about 5 inches long.

Habitat: Our specimen was from Siliguri bazaar. Day gives—' Orissa, Bengal, Cachar and Burma, in which latter country I have taken it as high up as Mandalay.'

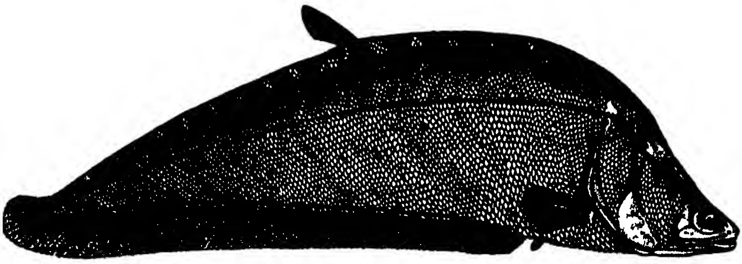
Group II.—THE FEATHER-BACKS.

[**Notopterus chitala** (Ham.)], *F.B.I.*, No. 520.

Plate 4, fig. 5.

Bengali: *Chital* চিতল; Hindi (Bihar): *Mohi* मोही.

D. 9-10. V. 5-6. 110–125 (135). C. 10. L. r. 225.



TEXT-FIG. 7.—*Notopterus chitala* (Hamilton).

In shape similar to *N. notopterus* but the back is more strongly humped in front and the ventral profile almost straight. There is also a more marked re-entrant curve above the eyes.

Colour: Silvery; dark along the back. There is a series of about 15 silvery transverse bars on each side of the dorsal ridge, some meeting the corresponding marks on the other side of the ridge, others alternating with them. There are 7 or 8 round black or dark grey spots irregularly arranged near the end of the tail. The dorsal is yellowish grey, the lower fins are almost white washed with silver on the basal half.

Size: We have seen them up to about 3 ft. long. Day says they attain at least 4 feet.

Habitat: We have only seen them in bazaars where they are commonly exposed for sale. Day gives—'Fresh waters of Sind, Lower Bengal, Orissa, Assam, Burma and Siam to the Malay Archipelago.'

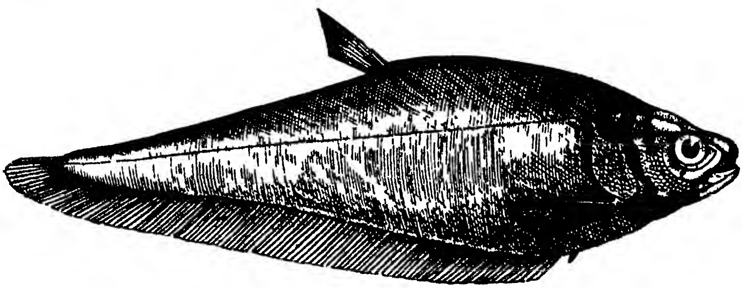
Notopterus notopterus (Pall.), *F.B.I.*, No. 519 *Notopterus kapirat.*

Plate 4, fig. 6.

Bengali: *Pholui* फलुई or *Phallai* फलई; Hindi (Bihar): *Golhi* गोलही; Hindi: *Pholi* पोली; Rabha: *Na-p(h)uli* Mechi: *Na-laithu.*

D. 7-8. V. 5-6. A. 100–110. C. 19. L. r. 225.

Laterally compressed, dorsal and ventral profiles both convex; the whole appearance rendered unusual by the long anal fin which extends for more than two-thirds of the whole length of the fish and is confluent with, and almost masks, a very small caudal. The dorsal is short and the pelvics very small.



TEXT-FIG. 8.—*Notopterus notopterus* (Pallas).

Colour: Silvery; Day mentions fine greyish spots everywhere.

Size: We have had them up to 10 inches long; Day says they attain 2 ft. or more.

Habitat: Clear streams of the Terai and Duars. Day gives—'Fresh and brackish waters of India to the Malay Archipelago'.

Group III.—THE SNOW-TROUT.

Oreinus molesworthii Chaudhuri.

1913. —*Oreinus molesworthi*, Chaudhuri, *Rec. Ind. Mus.*, VIII, p. 247, pl. vii, fig. 2.

Known as 'Snow-trout' though perhaps this name is more properly applied to *Schizothorax progastus*.

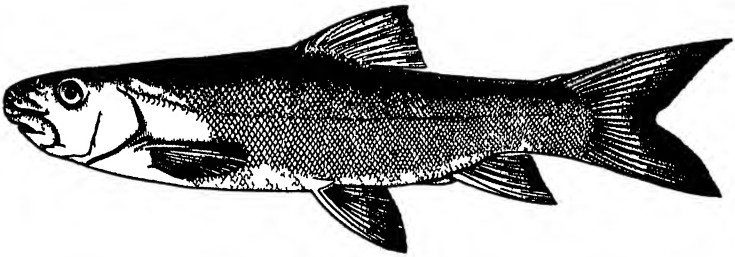
Nepalese : *Asla* असला ; Lepcha : *Moui*.

D. 3/8. P. 17. V. 10. A. 2/5. C. 19. L. 1. 98–107. Barbels 2 pairs.

In general appearance somewhat like a trout but the mouth is inferior and the snout rounded. There is a suctorial disc on the chin formed by the edge of the lower lip. Some have many tubercles on the snout and an incipient groove. Length of head 6, of caudal 6¾, height of body 5 in the total length.

Barbels : Very short, usually hidden in a fold of upper lip.

Fins : Caudal deeply forked. *Scales* very small and not very evident (Shaw), those immediately behind the gill-opening and below the lateral line rudimentary (Hora, *Rec. Ind. Mus.*, XXII, p. 734, 1921). Vent and base of anal in a sheath formed of enlarged, imbricate scales.



TEXT-FIG. 9.—*Oreinus molesworthii* Chaudhuri. (Copied from *Rec. Ind. Mus.*).

Colour : Brownish-grey above indistinctly speckled with black (resembling a brown trout), silvery below ; sides often shot with gold, a pinkish-brown tinge along the lateral line. Fins pale yellowish-brown or pinkish. Iris pale golden.

Size : Our longest 10·3 inches.

Habitat : Clear hill streams up to at least 2,000 ft. (Riyang) and probably higher. Common in some streams, *e.g.* the upper reaches of the Balasan River. The type specimen was from the Abor hills.

Habits : Mr. Curry informs us that they will take a fly which seems strange in a fish with such a mouth.

Schizothorax progastus (McClell.), *F.B.I.*, No. 286.
The 'Snow-trout'.

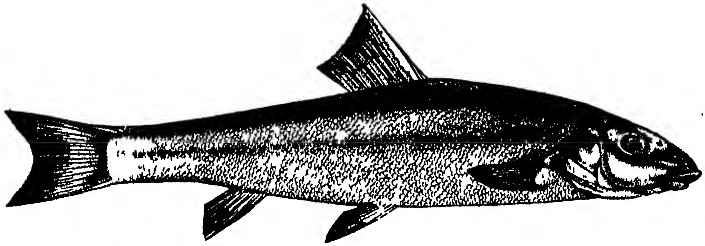
Nepalese: *Asla* असला (so called in Tibet by Sherpas who presumably do not distinguish it from *Oreinus molesworthii*).

D. 3/8–10. P. 10. V. 11. A. 2/5. C. 19. L. l. 150–190. Barbels 2 pairs.

In general appearance it resembles *Oreinus molesworthii*, with which we at first confused it, but the mouth is rather more forward and there is no sucker on the chin.

Fins: The caudal is forked; the dorsal has a strong, serrated, osseous ray.

Scales: Minute and not very distinct; a tile-like row (as in *Oreinus*) on the anal sheath.



TEXT-FIG. 10.—*Schizothorax progastus* (McClelland).

Colour: Day gives—'Uniform silvery, sometimes having a few fine spots; fins with darkish edges.' We have not had an opportunity of describing a fresh specimen.

Size: Day gives—'At least 20 inches in length.'

Habitat: Found from the headwaters of mountain streams downstream, apparently, as far as the plains; our own specimens were probably none of them from higher than about 2,000 ft. though we have seen them taken from the Torsa at least as high as Yatang in the Chumbi valley (9,800 ft.) and it is the commonest species in the streams of the plateau of Southern Tibet at an elevation of about 14,000 ft. Day gives—'Himalayas, from 'the headwaters of the Ganges to Sadiya in Upper Assam. 'Common at Hardwar, where the Ganges debouches into the 'plains.'

Group IV.—THE CARPS.

KEY TO THE CYPRYNIDÆ (THE CARPS) IN THIS LIST.

Abdominal edge cutting :—

Scales of moderate size (L. l. 34–37) .. .. *Laubuca* (p. 20)
Scales small (L. l. 86–110) .. .. .. *Chela* (p. 19)

Abdominal edge rounded :—

Dorsal begins before or opposite to front of Pelvics :

A suctorial disc on chin .. .. .. *Garra* (p. 48)

No suctorial disc on chin :—
- A line of open pores across snout .. *Semiplotus* (p. 59)
- Pores, if present, irregularly arranged :—
  - A tubercle in centre of lower jaw :—
    - Dorsal 15-16 rays, L. l. 40–45 .. *Cirrhina* (p. 43)
    - Dorsal 10–12 rays, L. l. 35–40 .. *Crossocheilus* (p. 47)
  - No tubercle in centre of lower jaw :—
    - L. l. 71–84, leaden rather than silvery *Labeo gonius* (p. 54)
    - L. l. 44–47, bright silvery .. *Barbus chagunio* (p. 35)
    - L. l. 36–44 :—
      - One or two pairs barbels .. .. *Labeo spp.* (p. 50)
      - No barbels .. .. .. *Catla* (p. 44)
    - L. l. 34 or less *Barbus spp.* (including *Cyclocheilichthys* and *Lissocheilus*, p. 45) (p. 33)

Dorsal begins distincly behind front of Pelvics but does not extend above Anal :—
- Opening of mouth wavy, three prominences on lower jaw fitting into corresponding notches in upper jaw *Rasbora* (p. 31)
- Opening of mouth normal :—
  - L. l. incomplete (about 15 scales) *Amblypharyngodon* (p. 31)
  - L. l. complete :—
    - Anal 29 rays or more .. .. *Rohtee* (p. 58)
    - Anal 12 rays or less .. .. *Aspidoparia* (p. 32)

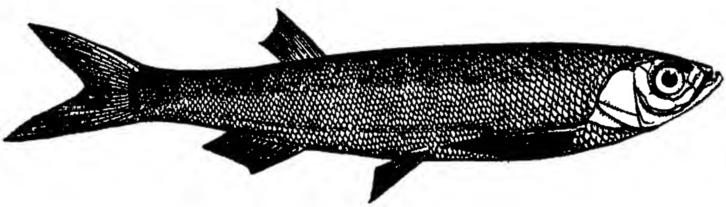
Dorsal begins opposite interspace between Pelvics and Anal and extends above the latter :—
- Cleft of mouth deep; blue spots or bands, if present, arranged vertically; Dorsal 9–11 rays .. *Barilius* (and *Raiamas*) (p. 21)
- Cleft of mouth shallow; colour pattern, if present, arranged horizontally :—
  - Anal 12 rays or more .. .. *Danio* (p. 26)
  - Anal 8 rays .. .. .. *Esomus* (p. 29)

Chela bacaila Ham., *F.B.I.*, No. 458.

Plate 2, fig. 14.

The Chilwa.

Bengali : *Chela* চেলা ; Hindi (Bihar) : *Chilwa* चिलवा.
D. 9. A. 13–15. C. 19. L.l. 86–110.



TEXT-FIG. 11.—*Chela bacaila* Hamilton.

Somewhat compressed laterally, abdomen with a cutting edge behind the pectorals, the dorsal profile straighter than the

ventral. The lateral line is low, about three-quarters of the distance from the back to the belly. The mouth is directed upwards.

Colour : Bright silvery.

Size : Day says—'attaining at least 7 inches.' We have had them up to 5 inches but they are more commonly 3 or 4 inches in length.

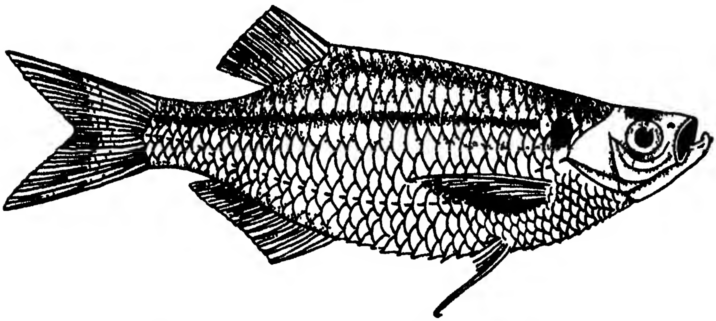
Habitat : Streams throughout the Terai and Duars. Day gives 'Throughout India except Malabar, Mysore and Madras and parts of the Deccan.'

Laubuca laubuca (Ham.), *F.B.I.*, No. 447
Perilampus laubuca.

Plate 2, fig. 16.

D. 11-12. P. 13. A. 19–23. C. 19. L. l. 34–37.

Somewhat deep and laterally compressed, abdomen with a cutting edge; mouth inclined upwards. Pelvic fins placed far forward and the dorsal far back. The lateral line is low, being more than three-quarters of the distance from the back to the belly.



TEXT-FIG. 12.—*Laubuca laubuca* (Hamilton).

Colour : Silvery; a black blotch near the base of the pectoral and sometimes another near the base of the caudal. Day mentions some yellow vertical stripes during life which we have not noticed.

Size : Day says it attains at least 3½ inches in length. Our longest was about 2½ inches.

Habitat : Our specimens were from the pond on the west side of the cart-road from Siliguri to Sukna immediately south of the Panchenai bridge. Day gives—'Ganjam, Orissa, Bengal, Central India, Assam, and Burma.'

Genus : *BARILIUS*, including *Râiamas*.

This genus is best known to anglers by its one sporting member, the *Bola* (Nepalese) or 'Hill-trout' (*Barilius bola*), but they may also have had a little fish in gleaming silver and blue (*B. barna*) attempt to take a spoon of nearly his own size, or have used him, or one of his less common relatives, as dead-bait.

All are bright, silvery fish common in clear, gravelly streams where the flesh of their bodies is the only visible sign of life in the dark of deep pools. All of them, at least when young, have some trace of the characteristic vertical pattern in transparent blue.

B. barila, *B. vagra* and the young of *B. bendelisis* are the most likely to be confused.

KEY TO THE SPECIES.

L. 1. 88–94, no barbels, a salmon-like hook on the lower jaw in adults ; a double row of blue blotches .. .. *B.* (*Raiamas*) *bola* (p. 23)

L. 1. 69–75, barbels rudimentary or none ; 2 or more rows of vertically elongated blue blotches .. .. *B. tileo* (p. 25)

L. 1. 60–70, 2 prs. barbels ; about 12 incomplete vertical bars, usually only visible across the back .. .. *B. shacra* (p. 24)

L. 1. 43–46, 1 pr. small barbels, A.3/10-11 ; 14-15 vertical blue bands in the middle third of the side .. .. *B. barila* (p. 21)

L. 1. 42–44, 2 prs. barbels, A.2-3/11-12 ; 7–14 vertical blue bands, sometimes indistinct .. .. .. *B. vagra* (p. 26)

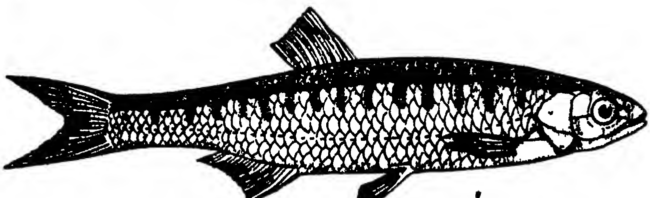
L. 1. 38–43, 2 prs. barbels, A.3/7-8, P. very large in males ; A black dot at base of each scale and double dots along L. 1. in adults, bars visible across back in young.. .. .. *B. bendelisis* (p. 23)

L. 1. 36–42, no barbels ; 9-10 well-marked blue bands from back almost to belly throughout life .. .. .. *B. barna* (p. 22)

Barilius barila Ham., *F.B.I.*, No. 427.

D. 9(2/7). P. 13. V. 9. A. 13-14(3/10-11). C. 19. L. 1. 43–46.

Barbels 1 pair (small, rostral). 'The adult has open pores on both jaws and snout. Length of head 5-5½, height of body 5¼–5½ in total length.' (*Day*)



TEXT-FIG. 13.—*Barilius barila* Hamilton.

Colour : 'Silvery, with 14 or 15 vertical blue bands in the middle third of the side of the fish.' (*Day*)

Size : 'Grows to 4 inches in length.' (*Day*) Our longest is 4¼ inches.

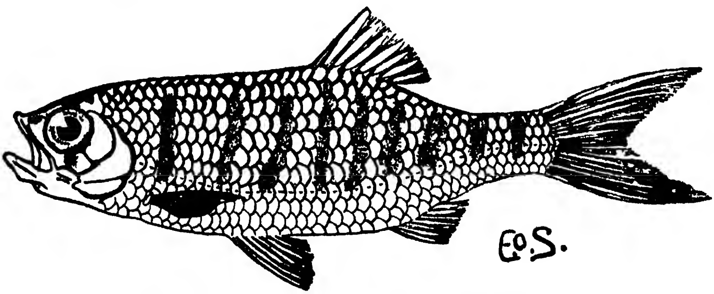
Habitat: Five of the specimens from our collection were identified as belonging to this species by Dr. Hora. At least one was from the Mahanadi River. Day gives—'Delhi, North-West and Central Provinces, Bengal, Orissa, and Lower Assam.' It is also found in Burma, see Mukerji, *Bombay Nat. Hist. Soc. Journal*, XXXVII, 1st. part (1934).

Barilius barna Ham., *F.B.I.*, No. 431.

Bengali: *Bhola* ভোলা or *Ghol* ঘোল; Nepalese: *Puti* पुटी, or *Fakatar* फकतार; Hindi (Bihar): *Darangni* दरंगनी,; Mechi: *Na-musha*; Rabha: *Na-korte.*

D. 9(2/7). P. 15. V. 9. A. 13-14(3/10-11). C. 19. L. l. 36–42. No barbels.

A deeper fish and more strongly compressed laterally than our other species of *Barilius*. There is also a tendency for the dorsal outline to be straighter than the ventral, and the mouth is directed slightly upwards. The adult has open pores on both jaws and snout. Length of head $4\frac{3}{4}$-$5\frac{1}{4}$, height of body $3\frac{1}{2}$-4 in total length.



TEXT-FIG. 14.—*Barilius barna* Hamilton.

Colour: Silvery with 9–11 well-marked bluish vertical bands, the first of which sometimes passes through the eye. Fins yellow, dorsal, caudal, and anal usually tinged with red. 'The young have the back grey, the sides silvery shot with gold, and from 7–9 deep blue vertical bands. Fins yellow, the dorsal and caudal stained externally with black.' (*Day*)

Size: Day gives—'Five inches or more' and we have had them up to about this size.

Habitat: Clear streams and even large rivers of the Terai and Duars, found in borrow-pits in the rains; very common. Day gives—'Assam, the Ganges and its branches, Bengal, and Orissa.' Also found in Burma, see Mukerji, *Bombay Nat. Hist. Soc. Journal*, XXXVII, 1st part (1934).

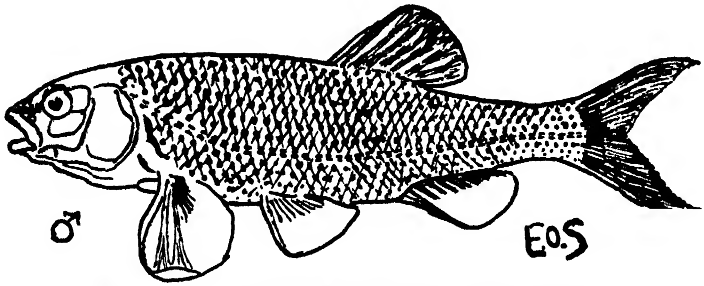
Habits: A voracious little fish, often taking a fly and even a spoon.

Barilius bendelisis var. **chedra** Ham., *F.B.I.*, No. 426.

Bengali: *Joia* জয়া; Mechi: *Elengi*; Rabha: *Na-pagli*; Nepalese: *Guderi* गुडेरी.

D. 9(2/7). P. 15. V. 9. A. 9-10(2-3/7-8). C. 18. L. l. 38–43. Barbels 2 pairs (minute). Rostral pair occasionally absent.

Shape normal, a sporting looking fish with beautiful lines. Hard rough pores above the mouth. Adult males have the pectorals very large and strong so that they might almost be taken for a different species. Length of head $4\frac{2}{3}$–$5\frac{3}{4}$, height of body $4\frac{1}{4}$-$4\frac{3}{4}$ (to $5\frac{3}{4}$ in the young) in total length.



TEXT-FIG. 15.—*Barilius bendelisis* var. *chedra* Hamilton.

Colour: Silvery with a black spot at the base of each scale and double spots on the lateral line. Day says that the spots are not present in the young, we have not noticed this though in some fish, irrespective of size, they may be very indistinct. Young fish have faint transverse blue-black bars across the back. A lemon-yellow wash on the opercle and black marks behind the gill openings. Fins yellow, pectorals, pelvics and anal tinged with orange, the hinder margin of the lower lobe of caudal black-edged.

Size: Day gives—'attains at least 6 inches' and we have had them up to about this size.

Habitat: Clear gravelly streams in the Terai and Duars. Day gives—'Assam and Himalayas, through the continent of India as far as the Western Ghats, not recorded from the coast of Malabar or Canara nor from Sind. Found also in Ceylon.'

Habits: 'The ova of this species are large; I found the fish breeding at Cuttack in the month of November.'

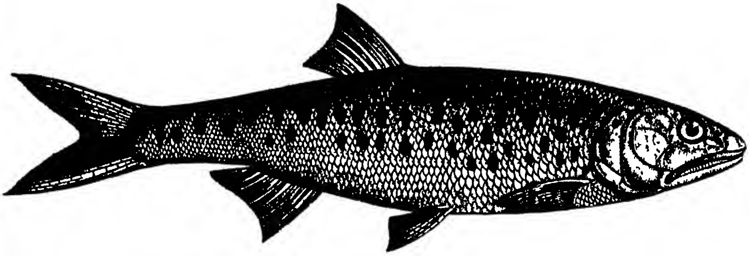
Barilius (Raiamas) bola Ham., *F.B.I.*, No. 435.

The 'Hill-trout.'

Bengali: . *Bhola* (?) ভোলা; Nepalese: *Bhola* भोला; Mechi: *Nalaida*.

D. 10-11(3/7-8). P. 13. V. 9. A. 13(3/10). C. 19. L. l. 88–94. No barbels.

Shape normal or rather slender. A well-developed knob on the symphysis of the lower jaw gives the deeply-cleft mouth a salmon-like appearance. Length of head 4¼-4⅜, height of body 5-6 in total length.



TEXT-FIG. 16.—*Barilius* (*Raiamas*) *bola* Hamilton.

Colour: 'Silvery, with two or more rows of vertical bluish blotches along the sides, the upper row with 12–20 blotches, and the lower intermediate; some spots also on the head. Lower half of the dorsal fin slightly grey. Caudal orange, stained with grey and black. Pectorals, pelvics and anal orange, the colours being somewhat similar to those of a trout.' (*Day*)

Size: Day gives—'Attaining at least a foot in length; one killed in Assam by Mr. Hannay is stated to have weighted 5 pounds.' We have seen them up to a foot but nothing to approach Mr. Hannay's fish.

Habitat: Clear streams and rivers of the Terai and Duars appearing to be more plentiful towards the east of our area. Day gives—'Orissa, Bengal, North-West Provinces, Assam, and Burma.'

Habits: A very game fish taking both fly and spoon well. They are most frequently caught at a junction.

Barilius shacra Ham., *F.B.I.*, No. 425.

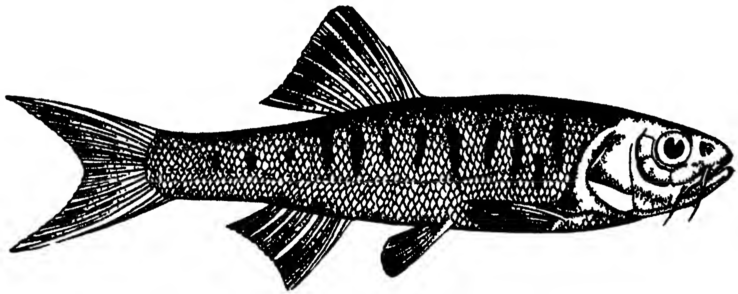
Plate 2, fig. 4.

Bengali: *Koksa* কক্সা; Mechi: *Na-boma*. (These names may refer to *B. vagra*).

D. 9(2/7). P. 15. V. 8. A. 10(2/8). C. 19. L. l. 60–70. Barbels 2 pairs.

Much the same shape as *B. vagra*, which it somewhat resembles except for the much smaller scales. Maxillary barbels as long as the eye, rostral pair slightly longer. Length of head 5-5¼, height of body 5-5½ in total length.

Colour : 'Back olive, rest of the body pinkish silvery; about 12 incomplete bars from the back downwards towards the lateral line, a dark bar along upper third of the dorsal fin. The lower $\frac{2}{3}$ of the vertical fins stained in some examples.' (*Day*)



TEXT-FIG. 17.—*Barilius shacra* Hamilton.

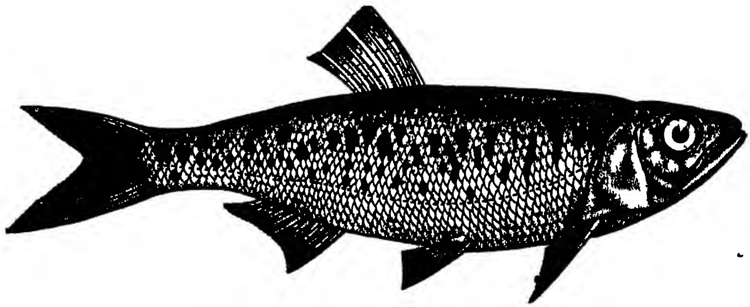
Size : 'It is said to attain 5 inches in length.' Our specimens have been smaller.

Habitat : Clear streams of the Terai and Duars, not common. Day gives—'From Hurdwar down the valley of the Ganges, North-West Provinces, and Assam.'

Barilius tileo Ham., *F.B.I.*, No. 433.

D. 9(2/7). P. 14. V. 9 A. 13(3/10). C. 20. L. 1. 69–75. Barbels rudimentary or entirely absent.

'Abdominal profile more convex than the dorsal. Head compressed, snout pointed. Length of head $4\frac{3}{4}$-$5\frac{1}{4}$, height of body $4\frac{2}{3}$ in the total length.' (*Day*)



TEXT-FIG. 18.—*Barilius tileo* Hamilton.

Colour : 'Bluish along the back, becoming silvery on the sides and beneath; two or more rows of blue spots and blotches, having a vertical character, along the sides. Dorsal and

caudal fins dark grey, with a light pinkish edge; the other fins yellowish.' (*Day*)

Size: Day gives 'at least 5 inches in length.' Our largest specimen measured 5-6 inches.

Habitat: Our three specimens were obtained by Mr. C. M. Inglis at Chilapata, Central Duars. Day gives—'Bengal and Assam.'

Barilius vagra Ham., *F.B.I.*, No 422.

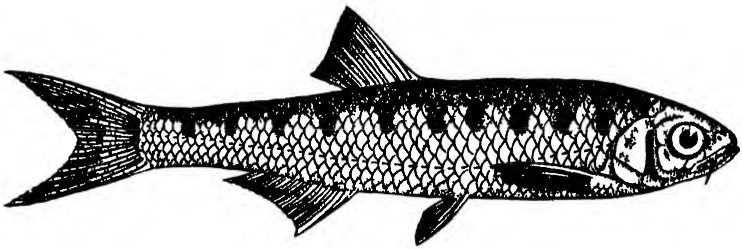
Plate 2, fig. 10.

Bengali: *Koksa* কক্সা; Mechi: *Na-boma.* (These names may refer to *B. shacra.*)

D. 9(2/7). P. 16. V. 9. A. 13–15(2-3/11-12). C. 19. L. 1. 42–44. Barbels 2 pairs.

Shape normal or rather slender. Lower jaw slightly the longer and, in adults, covered with large pores. Rostral barbels nearly half as long as the head, maxillary pair very short.

Length of head 5-6½, height of body 5-6 in total length.



TEXT-FIG. 19.—*Barilius vagra* Hamilton.

Colour: Silvery with a series of 7 to 14 blue vertical bands, sometimes indistinct, between the dorsal ridge and lateral line. Fins yellowish, edge of caudal stained grey.

Size: Day gives—'attains above 5 inches'. Our specimens were smaller.

Habitat: Clear streams of the Terai and Duars, not very common. Day gives—'Sind hills, rivers in the Himalayas and sub-Himalayan range, Jumna and Ganges, also the Punjab, Assam, and Ceylon.'

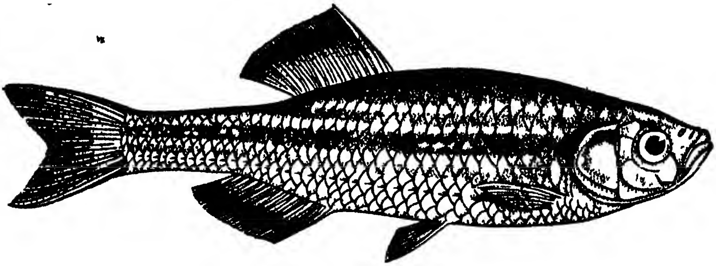
Danio æquipinnatus (McClell.), *F.B.I.*, No. 439.

Plate 2, fig. 15.

Bengali: *Chebli* চেবলী; Nepalese: *Bhiti* भीती.

D. 12–16. V. 8. A. 14–18. C. 19-20. L. 1. 32–36. Barbels 2 pairs (maxillary pair minute).

Shape similar to that of *D. devario* but not so deep. Length of head 5, height of body $3\frac{3}{4}$–$4\frac{1}{2}$ in total length.



TEXT-FIG. 20.—*Danio æquipinnatus* (McClelland).

Colour: A beautiful silvery fish with blue and orange iridescence on horizontal bands. Fins yellow. 'Dorsal and anal fins each with a broad bluish band along their outer half. In some specimens there is a dark mark behind the gill-opening.' (*Day*)

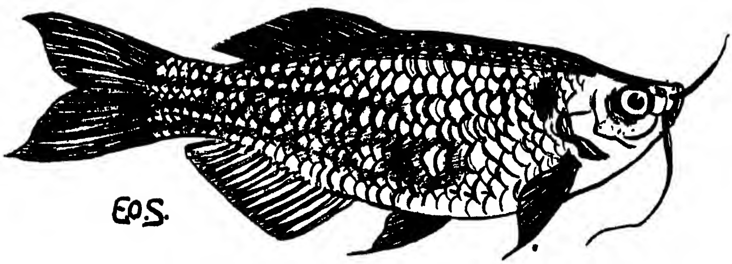
Size: Attains about 5 inches.

Habitat: Clear waters in the Terai and Duars where it is common, also all streams in the hills up to 3,000 ft. Day gives—'Himalayas of Darjeeling and the whole of the Assam District as high as Sadiya, the Naga and Garo Hills, Tenasserim and the Deccan.'

Danio dangila Ham., *F.B.I.*, No. 440.

Bengali: *Nipati* নিপাতী; Mechi: *Laupati*; Rabha: *Na-pa(t)-paru*; Chota-Nagpuri: *Durwa* डुरवा.

D. 11–13. P. 13. V. 7-8. A. 16–18. C. 20. L. l. 38. Barbels 2 pairs.



TEXT-FIG. 21.—*Danio dangila* Hamilton.

Shape intermediate between that of *D. devario* and *D. aequipinnatus*. Rostral barbels a little shorter than the head, maxillary pair slightly longer. Length of head 5, height of body $3\frac{1}{2}$-4 in total length.

Colour: Silvery with three parallel longitudinal blue or dark lines running from somewhere behind mid-body to half way along the tail. A black spot behind the gills.

Size: Day gives—'grows to 5 or 6 inches.' We have not had them quite so large.

Habitat: Clear streams of the Terai and Duars. Day gives—'Bengal, Bihar, Himalayas at Darjeeling, also the hills above Akyab.'

Habits: Lives longer in stale water than any fish except *Ophicephalus*.

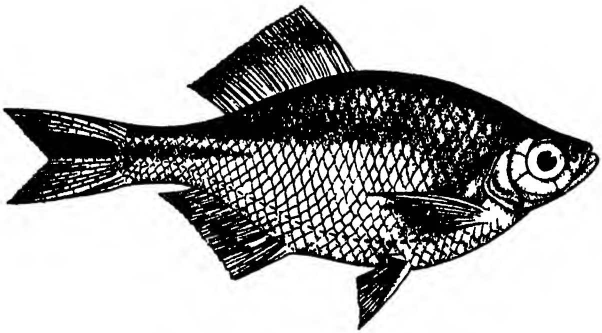
Danio devario Ham., *F.B.I.*, No. 436.

Plate 2, fig. 5.

Bengali: *Baṅs-pata*[1] বাঁশপাতা; Mechi: *Laupati*.

D. 18-19. A. 18-19. C. 19. L. 1. 41–48. No barbels.

Very deep and laterally compressed; the dorsal fin is set far back. The head is rather small. Length of head 5-5¼, height of body 3-4 in total length.



TEXT-FIG. 22.—*Danio devario* Hamilton.

Colour: Silvery with one bluish band of iridescence roughly following the lateral line from a point opposite the front of the dorsal to the end of the caudal. The colour is most marked on the tail and caudal. There are sometimes a pair of fainter blue bands, one above and one below that already described on the hinder part of the body and separated from it by golden colour. The post-orbital plates strikingly silvery. Day gives—'Greenish above, silvery white below. The anterior part of the body is reticulated in its centre by steel-blue lines, divided from one another by vertical yellow bands. Three bluish lines, divided by yellow ones, are continued backwards to the caudal fin, where

[1] This name is applied in S. Bengal to Cynoglossidæ.

the two lower amalgamate, and, passing upwards, become lost in the superior half of the fin.'

Size: Day gives—'attaining 4 inches in length.' We have had them about this size.

Habitat: Clear streams of the Terai and Duars. Day gives —'Sind, Orissa, Bengal, North-West Provinces, Deccan, Punjab, and Assam.'

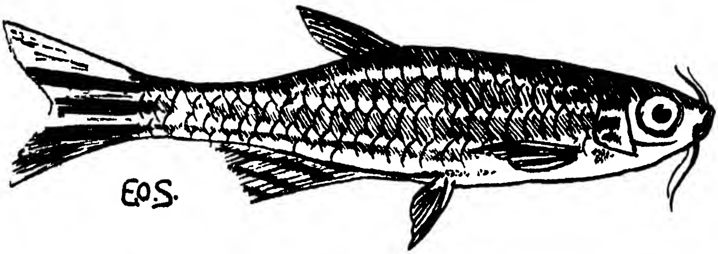
Danio (Brachydanio) rerio Ham., *F.B.I.*, No. 443.

The Zebra-fish of aquarists.

Bengali (Siliguri): *Anju* আঞ্জু.

D. 9(2/7). A. 15–16(2-3/12-13). C. 19. L. 1. 26–28. Barbels 2 pairs.

Shape normal. Rostral barbels short, maxillary pair reaching end of opercle. Length of head 5-5⅔, height of body 4⅔-5¼ in total length.



TEXT-FIG. 23.—*Danio* (*Brachydanio*) *rerio* Hamilton.

Colour: Four metallic blue longitudinal bands separated by three narrow silver ones. The three lower blue bands produced along the caudal fin. Anal with three blue bands.

Size: Day gives—'about 2 inches.' Our longest measured 1¼ inches.

Habitat: Edges of streams and ditches in the Terai. Day gives—'Bengal, and as low down the Coromandel coast as Masulipatam.' Also found in Burma, see Mukerji, *Bombay Nat. Hist. Soc. Journal*, XXXVII, 1st. part (1934).

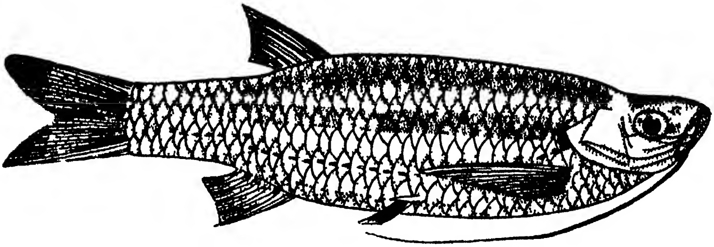
Esomus danricus (Ham.), *F.B.I.*, No. 409 *Nuria danrica*.

Bengali (local): *Dadhikha* দাধিখা (Lower Bengal) *Darrika* দারিকা; Rabha: *Daranki*.

D. 8(2/6). P. 15. V. 9. A. 8(3/5). L. 1. 30–34. Barbels 2 pairs.

Shape normal. Abdomen rounded. Mouth narrow, directed obliquely upwards. The longest barbels (maxillary) reach to the Dorsal situated far back, nearer to the caudal than

to the head. Length of head 5¼-5½, height of body 5 in total length.



TEXT-FIG. 24.—*Esomus danricus* (Hamilton).

Colour: Silvery; a broad black lateral band, sometimes absent.

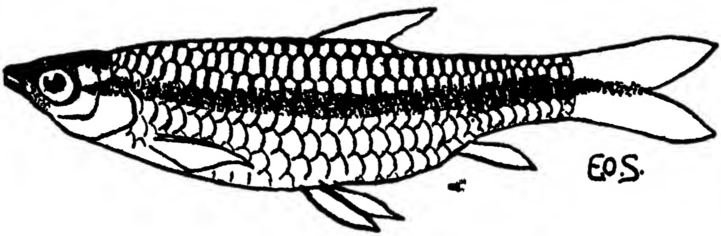
Size: Day gives 5 inches; our specimens have been smaller.

Habitat: The smallest streams, ponds, and ditches. Common during the rains in ditches in the forest. Day gives—'India, Ceylon, Burma, and the Nicobars.'

Habits: Day gives—'Dr. Cumberland found this fish in a hot stream of 112 degrees Far. at Pooree. (M. Regnaud in a hot stream at Cannia in Ceylon.)'[1]

Rasbora daniconius (Ham.), *F.B.I.*, No. 411.

Bengali (local): *Dadhikha* দাধিখা, or *Dankoni* দানকণি, or *Dhera* ধেরা, (South Bergal) *Darkina* দারকিণা; Mechi: *Dandikha*; Rabha: *Daranki*.



TEXT-FIG. 25.—*Rasbora daniconius* (Hamilton).

D. 9(2/7). P. 15. V. 9. A. 7(2/5). C. 19. L. l. 30–34. No barbels.

Shape normal or slender. The opening of the mouth is undulating (as described under *R. elanga.*).

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[1] *Note.*—The fish found by M. Regnaud have since been referred to *Esomus thermoicus.*

Colour: Silvery with a dark brown band along the lateral line from snout to tail. Head 5; height of body 5 in total length.

Size: Day gives—'attaining 8 inches in length.' Our longest specimen was about 6 inches.

Habitat: Clear but slow streams in the Terai and Duars. Day gives—'Continent of India, Ceylon, Burma, Malaya Archipelago, and Zanzibar.'

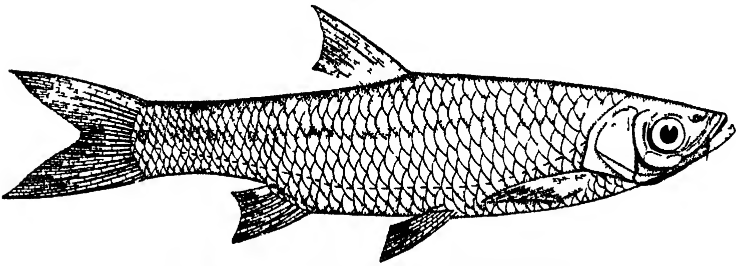
[**Rasbora elanga** (Ham.)], *F.B.I.*, No. 410.

Plate 2, fig. 13.

D. 9(2/7). P. 15. V. 8-9. A. 7(2/5). C. 19. L. 1. 40-44. Barbels 1 pair.

Shape normal. Abdomen rounded. Cleft of mouth oblique, lower jaw, having one central and two lateral prominences fitting into corresponding emarginations in the upper jaw; this gives the mouth a wavy opening when viewed from the front.

One short rostral pair of barbels. Caudal forked. Length of head 5-5¾; height of body 4½-5 in total length.



TEXT-FIG. 26.—*Rasbora elanga* (Hamilton).

Colour: Silvery, with sometimes a leaden-coloured band along the upper portion of the side.

Size: Day gives—'attaining at least 8 inches.' Our only specimen was about 6 inches long.

Habitat: Our only specimen was from Siliguri bazaar. Day gives—'Bengal, Assam, and Burma.'

Amblypharyngodon mola (Ham.), *F.B.I.*, No. 335.

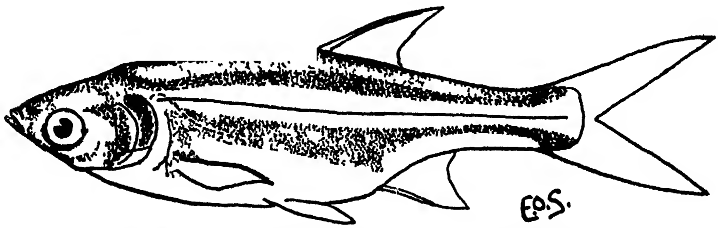
Plate 5, fig. 4.

Bengali (local): *Mowa* মউয়া, or *Mowka* মউকা (in Southern Bengal): *Mowrala* মউরলা; Rabha: *Elenga*.

D. 2/7. P. 15. V. 9. A. 2/5. C. 19. L. 1. 65–75. Barbels nil.

Mouth anterior cleft to within a short distance of a vertical line drawn through anterior edge of orbit. Body moderately compressed. Eyes rather large 3-3½ (3½-4 *Day*) in the length of head. In our specimens there are two lateral lines an upper one complete and a lower, crooked but more distinct one extending for about 15 scales from gill opening. Length of head 4¼-5, of caudal 4½ (5 *Day*), height of body 4-4½ in the total length.

Fins: Caudal deeply forked, lobes pointed. Dorsal commences behind the pelvics and extends nearly to above anal. *Scales* minute.



TEXT-FIG. 27.—*Amblypharyngodon mola* (Hamilton).

Colour: Greyish with a silvery longitudinal band about ¼ of body in depth extending along the upper lateral line from the gill-covers to the base of the caudal. The whole body covered with minute black dots.

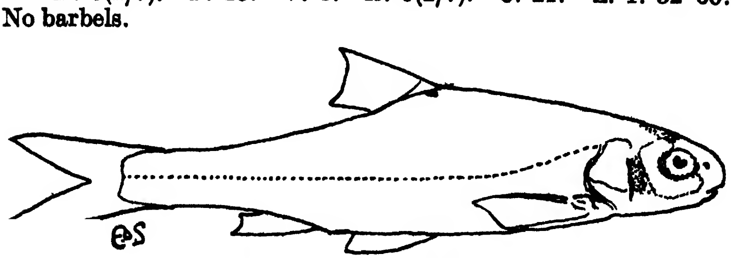
Size: Our longest 2½ inches.

Habitat; Streams and borrow-pits in the Terai and Duars. Day gives—'From Sind throughout India (except the Malabar Coast), Assam, and Burma.'

Aspidoparia jaya (Ham.), *F.B.I.*, No. 414.

Plate 2, fig. 8.

D. 9(2/7). P. 15. V. 8. A. 9(2/7). C. 21. L. 1. 52–60. No barbels.



TEXT-FIG. 28.—*Aspidoparia jaya* (Hamilton).

Shape normal; abdomen rounded. Mouth considerably overhung by the blunt snout. Length of head 5-5½, height of body 5 in total length.

Colour : Silvery.

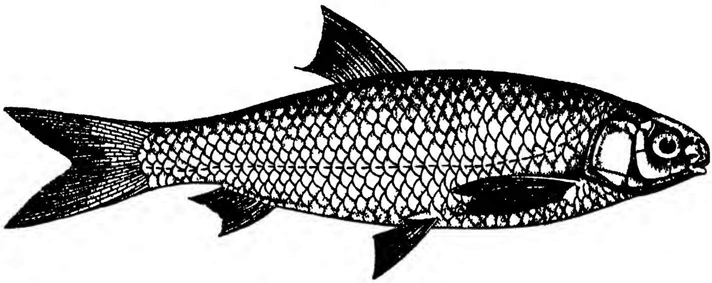
Size : The length of our only specimen was 4 inches.

Habitat : Our only specimen was from the Malangi river, Central Duars. Day gives—'Hardwar on the Ganges and Assam.'

Aspidoparia morar (Ham.), *F.B.I.*, No. 413.

D. 9-10(2-3/7-8). P. 15. V. 8. A. 10–12(2/8–10). C. 19. L. l. 38–42. No barbels.

Shape normal; abdomen rounded; mouth small, inferior, the lower jaw having a sharp crescentic edge destitute of lip. Snout very obtuse. Length of head 5-5¾, height of body 4–5½ in total length.



TEXT-FIG. 29.—*Aspidoparia morar* (Hamilton).

Colour : 'Back light brown, divided from the silvery side by a burnished streak.' (*Day*)

Size : Day gives—'attaining at least 7 inches in length'. Our specimens have been very much smaller.

Habitat : Borrow-pits on road-sides in the Terai. Day gives—'Sind, Punjab, Continent of India (except the Western Coast, and localities south of the Kistna River), also Assam and Burma.'

Genus BARBUS, including *Cyclocheilichthys* and *Lissocheilus*.

These fishes, which include the *Katli* and *Mahseer*, are strongly built with large scales which are metallic on their outer edges and dark at the base (in the last column of the table below an attempt has been made to describe their colours).

B. chagunio and *B. sarana* are easily distinguished by the count of lateral line. Of the rest *B.* (*Lissocheilus*) *dukai* and *B. putitora* (*Katli* and *Mahseer*) are large but, even in their young stages, marked by their comparative slenderness (the length of the body is always more than 4 times its depth). The remainder are all small fish (5 inches long or less) with 2 black marks on the

lateral line, a small one near the gill-opening and a large one on the tail. [In *B. stigma* these marks are sometimes missing and our specimens of *B.* (*Cyclocheilichthys*) ? *apogon* had no marks.]

Species.	L. l.	Barbels.	Spots on L. l.	Length / Depth.	Dorsal spine.	Colour of scales.
B. chagunio (p. 35).	42–47 on all scales.	2 pr.	none	4-4½	strong, serrate.	silver and black.
B. sarana (p. 41).	32–34 on all scales.	2 pr.	only in young.	3½-3¾	strong, serrate.	silver and black.
B. (*Lissocheilus*) *dukai* (p. 37)	25-26 on all scales.	2 pr.	none	4½	strong, smooth.	copper and green.
B. putitora (p. 39).	25–27 on all scales.	2 pr.	none	5½ (4½ young).	strong, smooth.	gold and green.
B. titius (p. 44).	24–26 on all scales.	1 pr.	tail and gills.	3-3½	strong, smooth.	silver and black.
B. conchonius (p. 36)	24–26 on 8–10 scales.	none	tail only.	2¾	strong, serrate.	silver and black.
B. ticto (p. 43)	23–26 on 6–8 scales.	none	tail and gills.	3-3½	strong, serrate.	silver and black.
B. phutunio (p. 39).	20–23 on 3-4 scales.	none	streaks	3-3½	strong, serrate.	reddish.
B. stigma (p. 42).	23–26 on all scales.	none	usually tail and gills.	3½-3¾	weak.	silver and green.
B. (*Cyclocheilichthys*) *apogon* (?) (p. 34).	21, on all (?)scales.	none	none	3½	strong, smooth.	silver and black.

Barbus (Cyclocheilichthys) ? apogon (Cuv. and Val.), *F.B.I.*, No. 387 *Barbus apogon*.

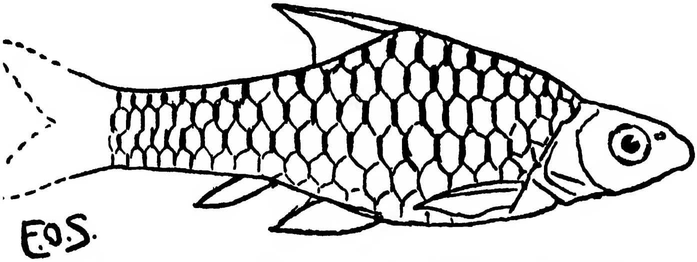
D. 4/8. P. 17. V. 10. A. 3/5. C. 19. L. l. 21. Barbels nil.

A single very imperfect specimen from the Terai has been identified by the Indian Museum as '*Cyclocheilichthys* probably *apogon*'. Our specimen does not agree well with *C. apogon* in the count of the lateral line which, though badly marked, was certainly not 36-37 as given for this species by Day.

We have also a note of a specimen from the Sivoke about 1920 which we cannot now find in our collection. This seems to agree to some extent with the above. The description reads : 'D. 2/8. P. about 10. V. 9. A. 7. C. 19. L. 1. 22. Barbels nil.'

A small fish like a *Barbus*. Length of head 4, depth of body 3⅓ into the total length.

Fins : All dorsal rays weak and not serrated. One dorsal ray very long, ⅓rd of total length of fish. (This was not so in the other specimen).[1]



TEXT-FIG. 30.—*Barbus* (*Cyclocheilichthys*) ? *apogon* (Cuvier & Valenciennes).

Colour : Silvery, a black spot nearer the tail than in *B. conchonius*, another fainter but larger one behind the shoulder. Top of the orbit black. *Fins*—top half of dorsal black, anal orange.'

Barbus chagunio (Ham.), *F.B.I.*, No. 339.

Plate 5, fig. 3.

Synonym :—*B. chagunio* var. *spilopholus* (referring to males) Day's *Fishes of India*. See Hora and Mukerji in *Journal of the Asiatic Society of Bengal* (N.S.), XXVII, p. 137.

Hindi : *Utta* उत्ता ; Mechi : *Dauka* ; Chota-Nagpuri : *Ḥilsaputi* हिलसा-पुटी.

D. 3/8. P. 15. V. 9. A. 3/5. C. 19. L. 1. 44–47. Barbels 2 pairs.

Upper profile in front of dorsal more arched than lower ; snout bold, covered with sunken pores more strongly marked and sharply defined in the male. Length of head 4½-5, of caudal 4⅔-5, height of body 4-4½.

Barbels : Rather longer than the orbit.

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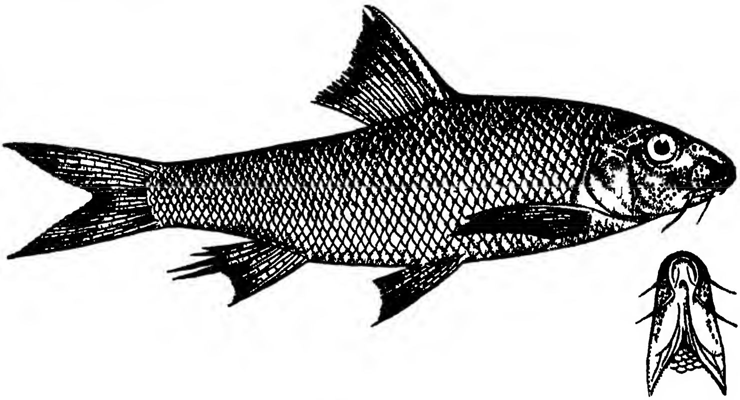
1 *Note.*—The lengthened dorsal ray was presumably a freak such as sometimes occurs in fishes. Dr. Hora notes that this is usually a secondary sexual character of the males and that elongation of rays occurs in quite a number of species.

Fins : Last undivided dorsal ray osseous, strong with coarse teeth. Some of the last few anal rays elongated in the male.

Colour: Silvery with a faint pinkish tinge; a black spot, at the base of each scale on the upper three-quarters of the body. Fins yellowish, dorsal and caudal with a suffused sub-marginal band of red touched with black. Pelvics and anal tinged with red. The male is more brilliant throughout and the black fin tips more marked.



TEXT-FIG. 31.—*Barbus chagunio* (Hamilton). Male.

Size : We have taken them up to a foot in length. Day says they attain at least 18 inches.

Habitat : Clear streams and rivers in the foot-hills, Terai and Duars. Day gives—'From Orissa, throughout Bengal, Assam, Bihar, and the N.W. Provinces to the Punjab but not recorded from Sind, the Deccan, Western Coast, Mysore, Madras, or Burma.'

Habits : It has been taken on a fly in the Balasan by casting downstream over a boulder into the pool below.

Barbus conchonius (Ham.), *F.B.I.*, No. 389.

Plate 5, fig. 13.

Bengali : *Kanchan-puṅti* কাঞ্চন-পুঁটি.

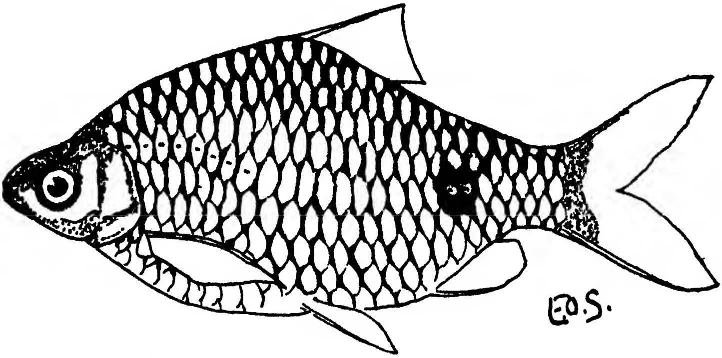
D. 3/8. P. 11. V. 9. A. 2/5. C. 19. L. 1. 24–26. Barbels nil.

Deeper and flatter than any other of our species of *Barbus*. The lateral-line ceases after 8–10 scales. Length of head $4\frac{2}{3}$-5, of caudal 4-$4\frac{1}{2}$, height of body $2\frac{2}{3}$ times in the total length.

Fins : Dorsal spine osseous and serrated.

Colour : Silvery, darker along the back and all scales with dark bases. A rounded black spot, diffused in young specimens

occupies about 19 and 20 of the lateral line. Fins transparent grey or pale yellow; pelvics and anal sometimes tinged with red or orange and sometimes dark. Upper lobe of caudal sometimes dark, the lower, or sometimes the whole reddish or orange. Iris golden or coppery. Day says—'opercles lake colour', we have never seen this.



TEXT-FIG. 32.—*Barbus conchonius* (Hamilton).

Size: Our longest 3½ inches. Day says—'attaining at least 5 inches in length'.

Habitat: Very common in all clear streams below 2,000 ft. Day gives—'Assam, Lower Bengal, Orissa, Bihar, N.W. Provinces, Punjab, and the Deccan.'

Barbus (Lissocheilus) dukai Day, *F.B.I.*, No. 352.

Plate 5, fig. 6.

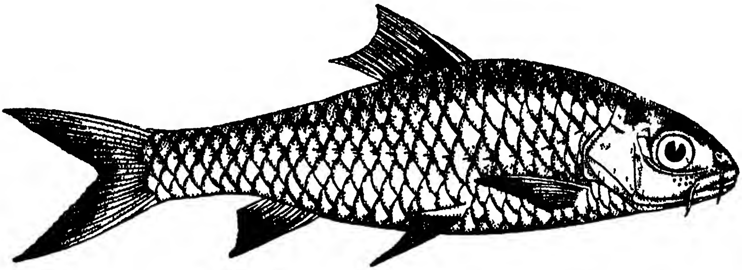
Note.—This fish, so well known to anglers in Northern Bengal under its Nepalese name, *Katli*, has hitherto been identified with *B. hexastichus*. As Day, in his *Fishes of India*, records that Dr. Duka took the type and several other specimens of *B. dukai*, from the Tista river it seemed strange that we had never come across this latter species. On turning up Day's figure of this, drawn from Dr. Duka's largest specimen, we were surprised to find a perfect and unmistakeable likeness of a small (7 inch) *katli*. This illustration, moreover, shows 26 scales on the lateral line, thus agreeing with our *katli* but not with Day's own text which gives 28-29 for *B. dukai*. This latter number appears to be an error by Day which he has repeated in his *Fauna of British India* volume. One of us has since examined all specimens of *B. hexastichus* and *B. dukai* in the British Museum but found the two series not easy to distinguish.

Assuming them to be distinct we think that no one familiar with the *katli* who examines Day's plates of *B. dukai* and *B. hexastichus* will doubt that Dr. Duka's fish were *katli*.

Bengali : *Bhorkol* ভর্কল or *Buluk* বুলুক ; Nepalese : *Katli* कतली ; Lepcha : *Mirpunja* ; Mechi : *Kantasi* ; Assamese : *Boka* (this may refer to *B. hexagonolepis*).

D. 3-4/9. P. 17. V. 9. A. 2/5. C. 19. L. l. 25–26.[1] Barbels 2 pairs.

In general appearance somewhat like *B. tor* but deeper, copper-coloured rather than golden, including the eye, with slate coloured, instead of yellow, fins. The positive distinction is in the presence of a double or treble row of even-sized pores below the eye. Length of head 5-5½, of caudal 4½-5, height of body 4½ in the total length.



TEXT-FIG. 33.—*Barbus* (*Lissocheilus*) *dukai* Day.

Colour : Olive green on back ; each scale above the lateral line copper-coloured at the edge deepening to bronze-green at the base. Below the lateral line the scales are pale slate-coloured fading to pure white on the belly. Fins deep slate-colour paling towards their margins. Iris bright coppery red.

Size : Rarely, if ever, exceeding 10 lb. in our area, but W. Nelson records a *Katli* of 25 lb. caught by him in the Champamoti near Gorubasha (Assam).

Habitat : In all rivers and clear streams in the foot-hills, Terai and Duars. Day gives—' Tista River, Darjeeling whence Dr. Duka sent me several examples.'

Habits : Very similar to those of the Mahseer. As a sporting fish there is nothing to chose between them, weight for weight. It is unfortunate that, as both take the same lures, and are found in the same water, the smaller species is often taken on much too heavy tackle which does not give him a chance to show his power.

[1] One specimen in the British Museum, L. l. 28 on one side and 25 on the other.

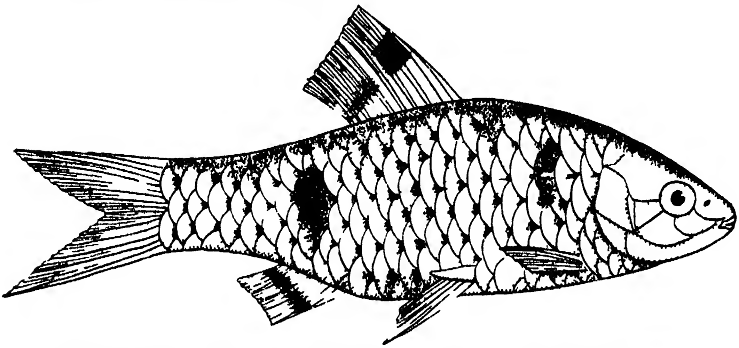
Barbus phutunio (Ham.), *F.B.I.*, No. 394.

Bengali : *Phutuni-punti* ফুটুনি-পুঁটি.

D. 2-3/8. P. 15. V. 9. A. 3/5. C. 19. L. 1. 20–23. Barbels nil.

Very like a small *B. conchonius*. The lateral line only extends for 3 or 4 scales from the gills. Day gives—'Length of head 4-4$\frac{2}{3}$, of caudal 4, height of body 3-3$\frac{1}{4}$ in the total length.'

Fins : Dorsal spine serrate.



TEXT-FIG. 34.—*Barbus phutunio* (Hamilton). Greatly enlarged.

Colour : Dirty white (reddish-brown *Day*) with two vertically elongated dark spots, one from the back to the base of the pectoral and another from the back to the base of the anal. According to Day, these grow shorter with age. There is an ill-defined dark band on the dorsal.

Size : Our longest 1 inch. Day says—'attaining 3 inches'.

Habitat : Ours from the Panchenai River (Terai). Day gives—'Ganjam, Orissa and through Bengal and Burma.'

Barbus putitora* (Ham.), *F.B.I.*, No. 353 *Barbus tor*, in part.

The Mahseer.

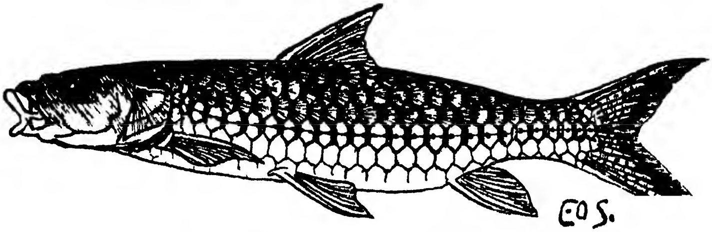
Plate 5, fig. 7.

**Note*.—Hora and Mukerji in a paper on the fishes of Dehra Dun, written after their tour there in 1935, have shown that the original *B. tor* of Hamilton Buchanan is the red-finned Mahseer or *Makhni* of Dehra Dun which does not occur in our area. Our Mahseer, known as the yellow-finned Mahseer in Dehra Dun, is identical with Hamilton's *B. putitora*.

Bengali : *Tor* তর, *Mahaser*, or *Mahasol* মহাসের or মহাশোল ; Nepalese : *Sor-machha* सोर माछ or *Saar* सार ; Mechi : *Jungia* (some Mechis call the light variety *Jungia* and the dark *Tor*).

D. 3/9. P. 19. V. 9. A. 2-3/5. C. 19. L. l. 25-27. Barbels 2 pairs.

In mature fish the dorsal and ventral profiles are nearly parallel, in young fish the dorsal is more arched. Lips very extensible, no pores on snout. In some specimens of both sexes lips and snout are greatly swollen, apparently a breeding phase. Length of head $4\frac{1}{4}$-$4\frac{3}{4}$, of caudal 5-$5\frac{3}{4}$, height of body $5\frac{1}{4}$ in the total length in mature fish; in smaller specimens these ratios are: head 5, caudal $4\frac{1}{2}$, height $4\frac{1}{4}$.



TEXT-FIG. 35.—*Barbus putitora* (Hamilton).

Barbels: Maxillary longer than rostral and extending to below the last third of the eye.

Fins: Spine of dorsal smooth but strong.

Colour: Olive green on back and top of the head, scales above the lateral line golden with dark bases, those below paling progressively to the white of the belly. Fins yellow, the lower ones often tinged with red; extreme redness of the lower fins sometimes associated with thick lips. Iris golden. A variable fish which appears to develop local varieties as the types which we recognize in our area do not agree with those described elsewhere. We distinguish three types, one darker and deeper and another slenderer and more silvery than that described above which is the intermediate and commonest form. One of our photographs of a specimen of the silvery type shows a dark band along the lateral line which we have seen more pronounced in photographs from Burma. The dark variety is in shape and colour intermediate between the typical *B. putitora* and *B. dukai*, but has no pores below the eye like the latter.[1]

Size: The heaviest fish which we know of having been caught in our area weighed 54 lb. and was caught by Mr. Ritchie at the junction of the Riyang with the Tista in August 1921. We believe the heaviest Mahseer ever caught on rod and line was Col. Rivett Carnac's from the Cauveri river which weighed 119 lb.

[1] I believe the three types of *Mahseers* referred to by Shaw and Shebbeare are (i) *B. putitora*, head longer than height of body, (ii) *B. hexastichus* McClelland, head as long as height of body, and (iii) *B. tor*, head shorter than height of body. It is quite possible that the large-scaled Barbels of Assam also occur in this area.—*S. L. Hora.*

Habitat : Small fish up to a few inches in length may be found in any clear gravelly stream in the Duars or Terai. Broadly speaking the larger the river the larger the *Mahseer* run. Day gives—'generally throughout India, but in the largest size and greatest abundance in mountain streams or those which are rocky'.

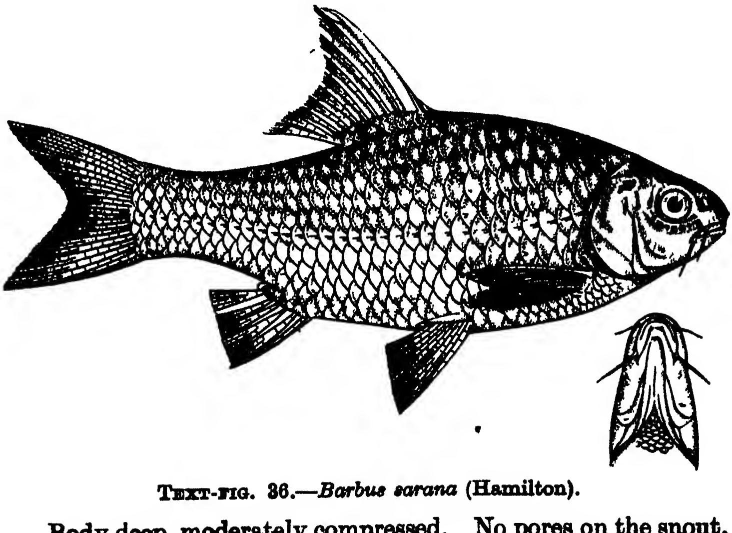
Habits : Considering that the *Mahseer* is the premier sporting fish of India, surprisingly little is known of its habits. They are said to have no definite spawning season but to lay their eggs a few at a time; we have, at any rate, taken fish with eggs throughout the cold weather. Judging by the distribution of young fish it would seem that they select slow, shallow, streams with gravelly beds to spawn in. We have also seen a few large fish in such streams. There seems to be no doubt that *Mahseer* appear to be travelling towards the headwaters of rivers at the beginning of the rains and downstream at the end, but this movement may be merely to avoid spates and be unconnected with spawning.

Barbus sarana (Ham.), *F.B.I.*, No. 341.

Plate 5, fig. 2.

Bengali (local) : *Kurti* কুর্তী, (Lower Bengal) *Sarna-punti* স্বর্ণ-পুঁটি ; Rabha : *Na-Cheren.*

D. 3/8. P. 15. V. 9. A. 3/5. C. 19. L. 1. 32–34. Barbels 2 pairs.



TEXT-FIG. 36.—*Barbus sarana* (Hamilton).

Body deep, moderately compressed. No pores on the snout. Length of head 5-$5\frac{1}{4}$, of caudal $4\frac{3}{4}$-5, height of body $3\frac{1}{2}$-$3\frac{2}{3}$ in the total length.

Barbels: *Rostral as long as the orbit; maxillary a little longer.*

Fins: Dorsal spine finely serrate.

Colour: Silvery, darker on the back, a golden blotch on the opercle; sometimes a small dark spot behind the gill-opening. Young have a faint black spot covering 25th to 28th scales on the lateral line. Fins greyish-white, caudal, pelvic and anal fins tipped with red.

Size: Our longest 10½ inches; 'at least a foot', *Day*.

Habitat: Clear streams of the foot-hills, Terai and Duars also ponds and borrow-pits. Day gives—'Sind and the Punjab, throughout India, Assam, and Burma.'

Barbus stigma[1] (Cuv. *and* Val.), *F.B.I.*, No. 398.

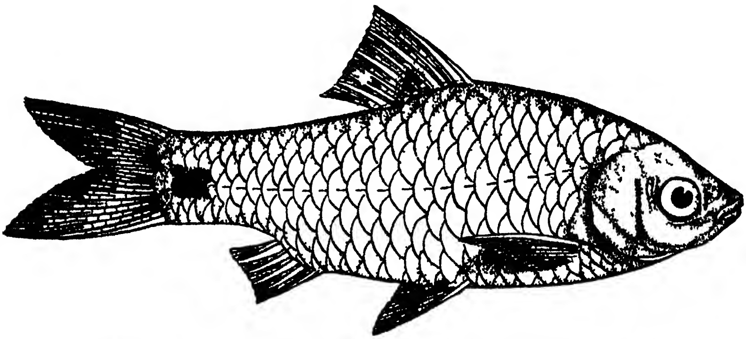
Plate 5, fig. 1.

Bengali: *Punti* পুঁটি; Mechi: *Puti-krei.*

D. 3/8-9. P. 17. V. 9. A. 3/5. C. 19. L. 1. 23–26. Barbels nil.

Very like *B. titius* in general appearance but lighter and more yellowish in colour (owing to the colour of the bases of the scales), and without barbels. Lateral line complete. Length of head 4⅔-5, of caudal 5, height of body 3-3⅓ in the total length.

Fins: Dorsal spine rather weak, entire.



TEXT-FIG. 37.—*Barbus stigma* (Cuvier and Valenciennes).

Colour: Silvery with yellowish bases to the scales. Usually, but not always, a black spot with diffuse edges covering the whole of 20th scale on lateral line and partly covering the 6 adjacent scales. There is a smaller black mark close to gill-opening and an orange-golden spot just behind and below the eye. Fins

[1] This is the same fish as *Barbus sophore* (Ham.).

almost colourless, a diffuse transverse dark band on dorsal (or sometimes a dark central spot). A reddish or orange wash on outer margin of dorsal and tips of pelvics and anal, the former the brighter. Pectorals sometimes yellowish.

Size: Our longest 4 inches. Day—'at least 5 inches'.

Habitat: Very common everywhere below 2,000 ft. Day gives—'Sind, throughout India and Burma as high as Mandalay.'

Barbus ticto (Ham.), *F.B.I.*, No. 390.

Plate 5, fig. 10.

Bengali: *Tita-puṅti* তিৎ-পুঁটি.

D. 3/8. P. 15. V. 9. A. 2/5. C. 19. L. 1. 23–26. Barbels nil.

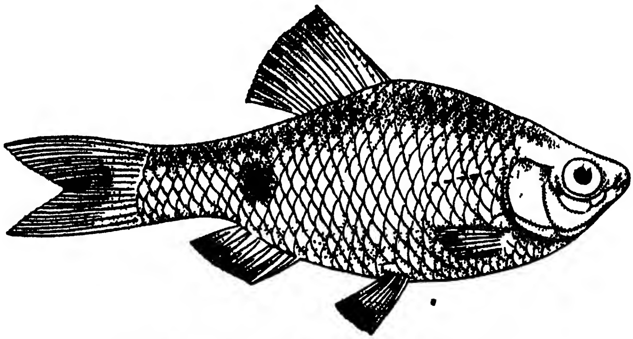
Not so deep as most of the black-spotted barbels. The lateral line ceases 6–8 scales from the gill opening. Length of head $4\frac{3}{4}$-5, of caudal $4\frac{1}{2}$-5, height of body 3-$3\frac{1}{3}$ in the total length.

Fins: Dorsal spine strong, osseous and serrated.

Colour: Silvery, with two black spots on the lateral line, a smaller one a short distance behind the gills, on scale 3, and a larger one behind the base of anal, involving scales 18 to 21.

In the C.P. this fish turns brilliant red on the flanks and olive-green on the back from March to September. We did not notice this change here. Dr. Hora informs us that these are colour changes assumed by the males at the time of breeding.

Size: Our longest 1·4 inches. Day—'rarely exceeds 4 inches'.



TEXT-FIG. 38.—*Barbus ticto* (Hamilton).

Habitat: Our specimens are from the Mahanadi and Panchenai Rivers of the Terai. Day gives—'Sind, throughout India and Ceylon.'

Barbus titius (Ham.)

1822. *Cyprinus titius*, Hamilton, *Fish. Ganges*, p. 315.

Plate 5, fig. 5.

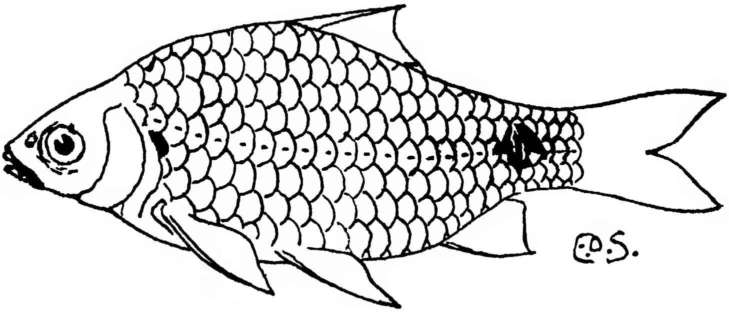
Bengali : *Punti* পুঁটি ; Mechi : *Na-pitikri* ; Rabba : *Na-Nishen.*

D. 2-3/8. P. 17. V. 9. A. 2/5. C. 19. L. l. 24–26. Barbels 1 pair.

One of the several species of deep, compressed forms of *Barbus* known as *Puti*. Length of head 4½-5 (4-4½ *Day*), of caudal 4½-5, height of body 3-3¼ in the total length.

Barbels : Maxillary, thin and ⅔rd length of orbit.

Fins : Dorsal spine osseous, smooth.



TEXT-FIG. 39.—*Barbus titius* (Hamilton).

Colour : Silvery with a black spot at the gill-opening and a larger one on the lateral line involving the 19th to 21st scales (18th to 20th, *Day*). Fins yellow, pelvics and anal with a reddish wash.

Size : Our longest 5 inches. Day says—'up to nearly 5 inches'.

Habitat : Streams of Terai and Duars ; also in ponds and borrow-pits. Day gives—'Orissa, Bengal, Assam, N.W. Provinces, Punjab and Sind, also the Deccan.'

[Catla catla (Ham.)], *F.B.I.*, No. 332 *Catla buchanani.*

Plate 5, fig. 9.

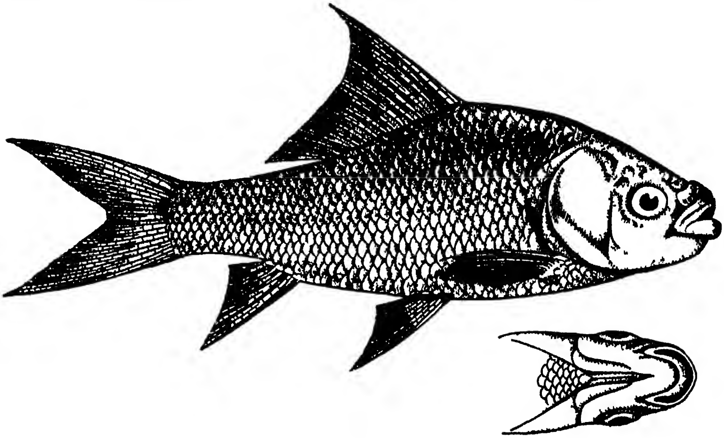
Bengali : *Katla* কাতলা ; Hindi : *Chepti* चेपटी.

D. 3-4/14–16. P. 21. V. 9. A. 3/5. C. 19. L. l. 38–43. Barbels nil.

Body deep, moderately compressed, head broad, mouth wide, lower jaw prominent with lip doubled outwards below. Length of head 4¼-4¾, of caudal 4¼-4¾, height of body 3-3½ in the total length.

Fins: Caudal deeply forked. Pelvics 'in males extends to the anal'. (*Day*)

Colour: Dark grey above, silvery on the sides and white on the belly. Scales, except those of the belly pink or coppery in the centre. Fins very dark grey ('in some specimens nearly black', *Day*) except the base of pectoral which is paler.



TEXT-FIG. 40.—*Catla catla* (Hamilton).

Size: Day says it attains at least 6 feet in length

Habitat: We have only seen them exposed for sale in bazaars. Day gives—'In fresh or brackish water—Sind, Punjab, through India to the Kistna, eastwards through Bengal, and Burma to Siam. This fish is largely employed for stocking tanks.'

[The range of *Catla catla* (Ham.) does not extend to Siam where it is replaced by an allied form *Catlocarpio siamensis* Blgr.—S. L. Hora.]

Habits: Day says it is said never to take a bait but rises to natural fly.

[**Cirrhina mrigala** (Ham.)], *F.B.I.*, No. 321.

Bengali: *Mrigala* মৃগাল; Nepalese: *Mirgal* मिरगल.

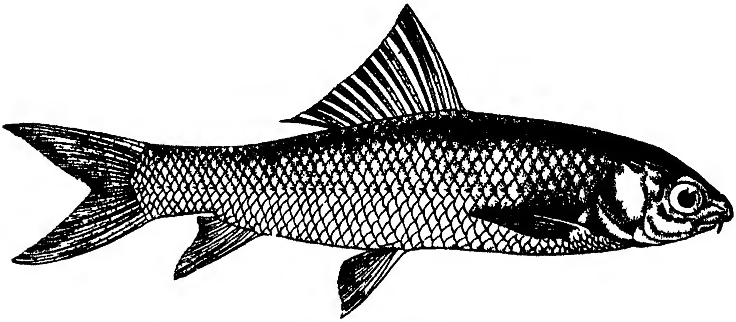
D. 3/12-13. P. 15. V. 9. A. 3/5. C. 15. L. 1. 40–45. Barbels 1 pair.

Very like a *Labeo* but with a wider mouth and thin lips. Pores on the snout in our specimens ('pores present or absent', *Day*). Lower jaw has a small tubercle in the centre. Day gives—'Length of head 5-5½, of caudal 5, height of body 4-5½, in the total length.'

Barbels: Small in fold of lip.

Fins: Caudal sharply forked. *Scales*: Large.

Colour : Dark grey along the back, silvery on the sides and below. Day says—' sometimes having a coppery tinge ; pectoral, ventral (*i e.* pelvics) and anal, orange stained with black. Eyes golden '.



TEXT-FIG. 41.—*Cirrhina mrigala* (Hamilton).

Size : Day says—' growing to 3 feet in length. I have taken it in Rangoon 18 lb. in weight '.

Habitat : We have only seen them exposed for sale in Siliguri bazaar. Day gives—' Rivers and tanks in Bengal, Deccan, N.W. Provinces, Punjab, Sind, Cutch, and Burma. It is an excellent species for stocking tanks with.'

Habits : It is said to give the best sport on rod and line of any tank-fish in Bengal.

Cirrhina reba (Ham.), *F.B.I.*, No. 323.

Plate 2, fig. 9.

Bengali : *Kharkebata* খড়ুকেবাটা, or *Raig* রাইগ ; Hindi : *Rewa* रेवा, *Raicheng* रैचेंग (Chapra district) ; Mechi : *Na-bhangna.*

D. 2-3/8-9. P. 16. V. 9. A. 3/5. C. 19. L. 1. 35–38. Barbels one pair.

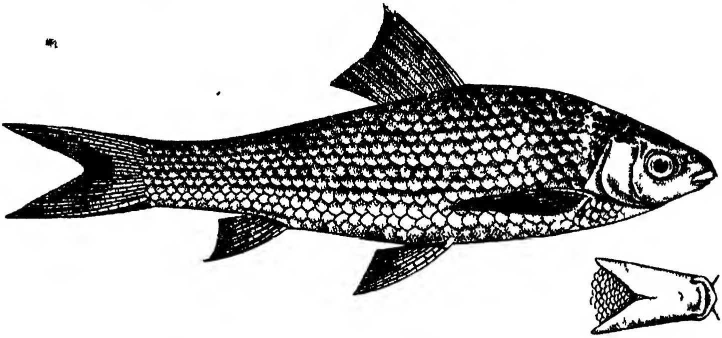
The description of *C. mrigala* will apply to this fish except that the barbels are rostral, short and rather stiff. (According to Day they may be absent.) Upper lip fringed in young. ' Pores on snout present or absent.' (*Day*) Length of head 6-6½, of caudal 4¾-5½, height of body 4-5 in the total length.

Barbels : See general description above.

Fins : Caudal deeply forked ; lobes sharply pointed. *Scales* hexagonal.

Colour : Dull silvery, scales darkest at their upper and lower edges forming bluish longitudinal lines above, and for two or three rows below, the lateral line. Pelvics and anal

tipped with orange. 'Young have sometimes a leaden band along the sides.' (*Day*)



TEXT-FIG. 42.—*Cirrhina reba* (Hamilton).

Size: Ours up to 9½ inches long. Day says one foot.

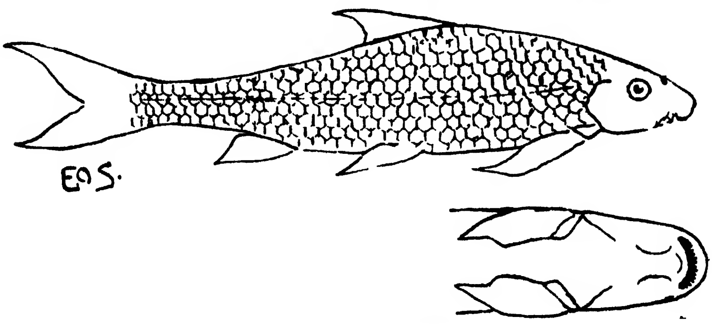
Habitat: Rivers and clear streams in the Terai and Duars. Day gives—'Throughout India.'

Crossocheilus latia (Ham.), *F.B.I.*, No. 322 *Cirrhina latia*. Plate 2, fig. 12.

(*Note.*—For sometime we confused this fish with *Garra annandalei*, hence the vernacular names we have recorded for both are open to doubt.)

Hindi: *Gauma* गौमा.

D. 3/7-8. P. 15. V. 9. A. 2/5. C. 19. L. l. 38–40. Barbels 2 pairs.



TEXT-FIG. 43.—*Crossocheilus latia* (Hamilton).

A very variable species (see Mukerji's note on the different races, *Bombay Nat. Hist. Soc. Journal*, XXXVIII, 1st part, 1934). It resembles *Garra annandalei* but is a slenderer and more graceful fish and has a more deeply forked caudal fin with more pointed lobes. Length of head 7 (*Garra* 5-5¾), height of

body 6¾ (*Garra* 5-6), vent to base of caudal 3½ (*Garra* 4½), height of caudal peduncle 12 (*Garra* 8½) in total length.

Barbels : Rostral pair half the length of the maxillary.

Colour : Grey above, with less colour than *Garra*, silvery beneath.

Size : Our longest 6 inches ; Day says it attains 8 inches.

Habitat : All hill streams from plains level to 2,000 ft. Day gives—'Sind, Orissa, Bengal, N.W. Provinces, Punjab, Deccan, and along the Himalayas.'

Habits : It behaves very like the Garras adhering to stones in stream beds.

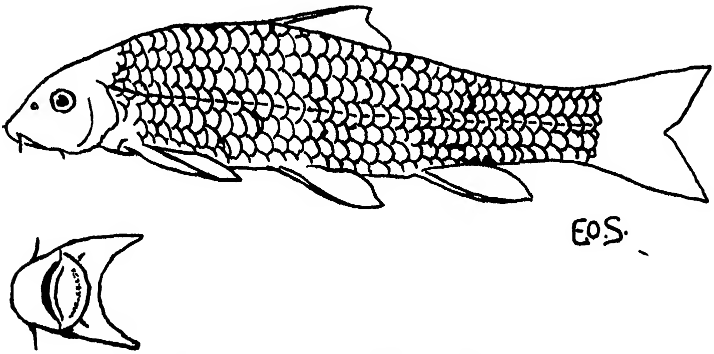
Garra annandalei Hora.

1921. *Garra annandalei*, Hora, *Rec. Ind. Mus.*, XXII, p. 657.

(*Note.*—For some time we confused this fish with *Crossocheilus latia*, hence the vernacular names we have recorded for each are open to doubt.)

Nepalese : *Lohari* लोहारी.

D. 2/9. P. 14. V. 9. A. 2/6. C. 21. L. l. 34–38. Barbels 2 pairs.



TEXT-FIG. 44.—*Garra annandalei* Hora.

Very like *G. gotyla* in all respects except that it has no groove across the snout nor tubercles upon it.

Size : Our longest was 6 inches.

Habitat : Found in the same streams as *G. gotyla* but less common.

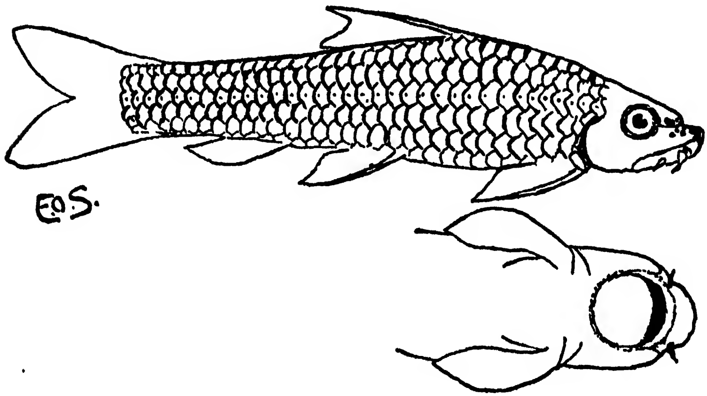
Garra gotyla (Gray), *F.B.I.*, No. 279 *Discognathus lamta*, in part.

Bengali : *Ghor-poia* ঘোরপোয়া ; Nepalese : *Budena** बुडेना ; Lepcha : *Momut* ; Mechi : *Chiltuka* ; Rabha : *Shetoka* or *Siltoka*.

**Note.*—The Nepalese word *budena* is also applied to a short, heavy kukri and probably refers to the stumpy shape of this fish.

D. 2–3/8–9. P. 15. V. 9. A. 2/5. C. 17. L. 1. 32–34. Barbels 2 pairs.

Body elongated, sub-cylindrical, mouth semi-circular inferior, a suctorial disc on the chin, upper lip fringed. Snout covered with pores or with conical tubercles and has a deep groove across it forming a proboscis. This groove is not determined by sex or by locality. Length of head 5¾ (5–5½, *Day*), caudal 5-6¼ (*Day*), height 5-6 (*Day*) in total length.



TEXT-FIG. 45.—*Garra gotyla* (Gray).

Barbels : One pair rostral and one pair maxillary, both about the length of the orbit.

Fins : Caudal shallowly lobed.

Colour : Yellowish to coppery green, fins darker and may be fringed with yellow or red. Sometimes a dark spot behind gill-opening.

Size : 'At least 8 inches in length.' (*Day*)

Habitat : Common in all clear streams from plains level to at least 1,600 ft. (Riyang River). Day gives :—'From Syria throughout India and Ceylon to the Tenasserim provinces, and likewise found in Abyssinia and at Aden.'

Day's *D. lamta*, however, includes also *G. annandalei* which has no proboscis and no tubercles.)

[*Garra gotyla* (Gray), as restricted at the present day, is found in the Chindwin drainage of Burma, Assam hills, along the Himalayas and the Vindhyas. A variety of this species has also been described from Ceylon.—S. L. Hora.]

Genus LABEO.

The remaining genera of the CARPS mostly lack the shining appearance of those already described; they are leaden rather than silvery. In *Labeo* the general colour is leaden though often the centre of each scale is paler than the margin, often pink or reddish (this is so in *Catla catla* also). These dark margins may coalesce to form dark, horizontal lines along the rows of scales (this is so in *Cirrhina reba* also). The lips and snout are fleshy, the lips being continuous round both jaws and the snout often covered with pores. *Labeo* are found in tanks and rivers, where they seem to be bottom-feeders.

It is not easy to key the somewhat variable species which we have found in our area.

L. l. 71–84	*L. gonius* p. (54)
L. l. 37–44	
22–24 branched dorsal rays	*L. nandina* (p. 55)
13–15 branched dorsal rays :—	
Height 3½-4 in total length	*L. calbasu* (p. 52)
Height 4-4½ in total length	*L. rohita* (p. 57)
11 branched dorsal rays :—	
Mouth wide (2½ in length of head)	*L. dyocheilus* (p. 53)
Mouth narrow (3¼ in length of head)	*L. pangusia* (p. 56)
9-10 branched dorsal rays :—	
A groove across snout	*L. dero* (p. 53)
No groove across snout :—	
Height 4-4½ in total length	*L. bata* (p. 50)
Height 5-5¼ in total length	*L. boga* (p. 51)

Labeo bata (Ham.), *F.B.I.*, No. 306.

Bengali (local): *Bhangna* (?) ভাঁগ্না, (Lower Bengal) *Bhangan-bata* ভাঙ্গনবাটা; Mechi: *Lengsa* (?).

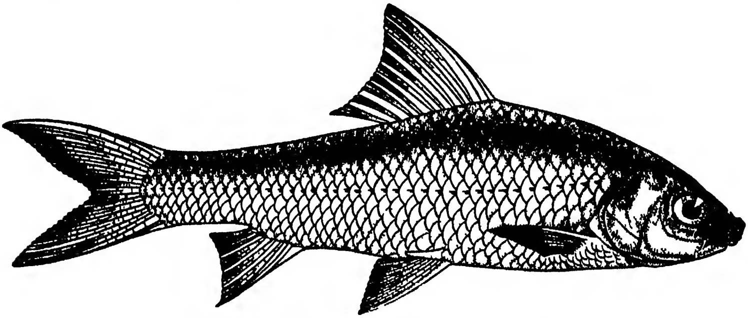
D. 2-3/9-10. P. 18. V. 9. A. 2/5. C. 19. L. l. 37–40. Barbels 1 pair.

We have only obtained one specimen identified as this species (by the Indian Museum) and our only notes on this, other than the vernacular names, are to the effect that it was a much more graceful fish than *L. boga*, which it otherwise resembled but had a narrower snout (Day gives the width of mouth for this species 3¼ into length of head as against 3 for *L. boga*). We have therefore extracted the following from Day: Length of head 5½-5¾, of caudal 5-5½, height of body 4-4½ in the total length.

Colour: 'Varies with the age of the fish; generally silvery, darkest along the back, and with the lower fins stained orange. Fine black dots on all the fins. When about four inches long there are three or four small black spots on the 5th and 6th

scales on the lateral line, which gradually and almost entirely fade as age advances.'

Size: Our specimen was 6¾ inches. Day says—'attains nearly 2 feet in length.'

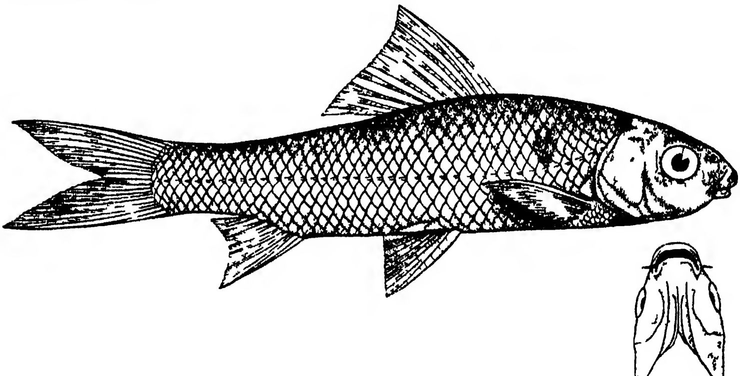


TEXT-FIG. 46.—*Labeo bata* (Hamilton).

Habitat: Our only specimen was from the Apalchand River in the west of the Duars. Day gives—'From the Kistna and Godavery Rivers, through Orissa, Lower Bengal, and Assam. Extensively used for stocking tanks.'

Labeo boga (Ham.), *F.B.I.*, No. 309.

D. 2-3/9-10. P. 16. V. 9. A. 2/5. C. 19. L. 1. 37-39. Barbels 1 pair.



TEXT-FIG. 47.—*Labeo boga* (Hamilton).

A somewhat robust fish. There are no lateral lobes to the snout which has a few large pores. Day gives—'Length of head 5¼-5½, of caudal 5, height of body 5½-5¾.'

Barbels: We have not found any; Day says there are two minute maxillary ones. Lips rather thick.

Fins : Caudal deeply forked.

Colour : Dark above, silvery on sides and below. Sometimes a dark spot on the shoulder. Opercle coppery. Fins covered with fine black dots, caudal quite red. Day gives—'Orange, with the fins of a reddish tinge.'

Size : Our longest 1 foot. Day gives—'Said to attain a foot in length'.

Habitat : All our specimens are from the Jaldhaka River (Duars). Day gives—'Rivers of the Gangetic Provinces, Madras, and Burma.'

Labeo calbasu (Ham.), *F.B.I.*, No. 293.

Plate 5, fig. 11.

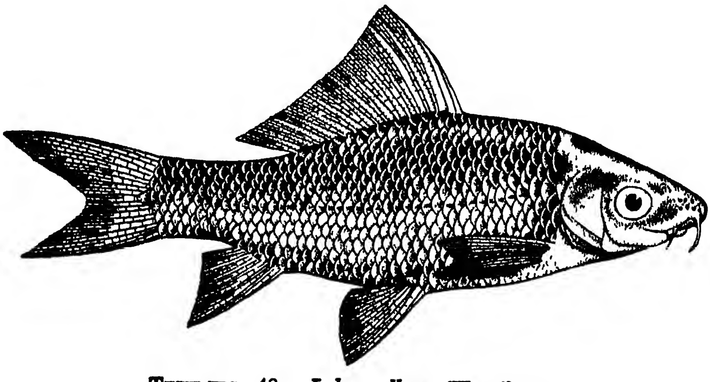
Bengali (local) : *Kursha* কুরসা, (Lower Bengal) *Kalbaus* কালবোস or *Kalbasu* কালবসু.

D. 3/13–15. P. 19. V. 9. A. 2/5. C. 19. L. 1. 40–44. Barbels 2 pairs.

A deep, stockily-built fish. Mouth rather narrow, snout obtuse and depressed, no lateral lobe. Pores on snout and upper lip, chin slopes away sharply from mouth. Length of head 5-6, of caudal 4-5, height of body 3½ (4, *Day*) in the total length.

Barbels : Rostral barbels slightly longer than maxillary and about equal in length to diameter of orbit.

Fins : Caudal deeply forked.



TEXT-FIG. 48.—*Labeo calbasu* (Hamilton).

Colour : Dusky—each scale with a pinkish buff (or even scarlet) centre and a dark (even blackish) margin; the margins sometimes form dark longitudinal lines. Fins dark. Iris rich coppery.

Size : Our largest specimen 20 inches long. Day writes—'It grows to three feet in length.'

Habitat: Deep pools in clear sluggish streams (*e.g.* Bania River) such as occur towards the South of our area. Day gives—'Punjab, Sind, Cutch, Deccan, Southern India, and Malabar, from the Kistna, through Orissa, Bengal, and Burma.'

Habits: It is said to be a tank fish and we understand that it gives good sport on rod and line.

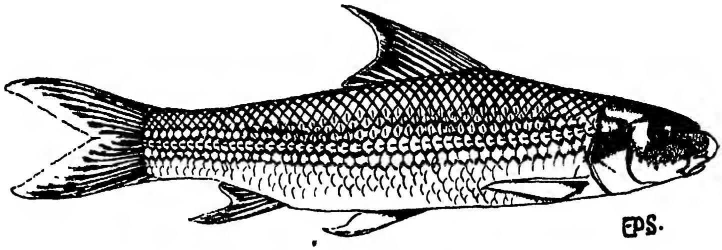
Labeo dero (Ham.), *F.B.I.*, No. 302 ***Labeo diplostomus*, in part.**

Plate 2, fig. 7.

Bengali: *Kursha* (?) কুরসা or *Katalkusi* কাটালকুশী; Hindi: *Bongsa* बोंगसा; Nepalese: *Gurdi* गुरदी or *Goddi* गोद्दी; Mechi: *Phunkeita.*

D. 2-3/9–10. P. 17. V. 9. A. 2/5. C. 19. L. 1. 41–44. Barbels 1 pair.

More slender than the species of *Labeo* hitherto described. The snout has a more or less deep groove across it and is covered with pores. There is no lateral lobe. Length of head 5-5½, of caudal 4¾-5, height of body 5-5½ in the total length.



TEXT-FIG. 49.—*Labeo dero* (Hamilton).

Barbels: A small maxillary pair, not always found.

Fins: Caudal deeply forked, upper lobe sometimes slightly the longer.

Colour: Dull silvery grey darkest along the back. Scales often, but not always, tinged with red or with a red vertical line on each one. Margins of scales sometimes forming dark longitudinal lines on flanks. Dorsal and caudal fins grey tinged with red, other fins salmon coloured.

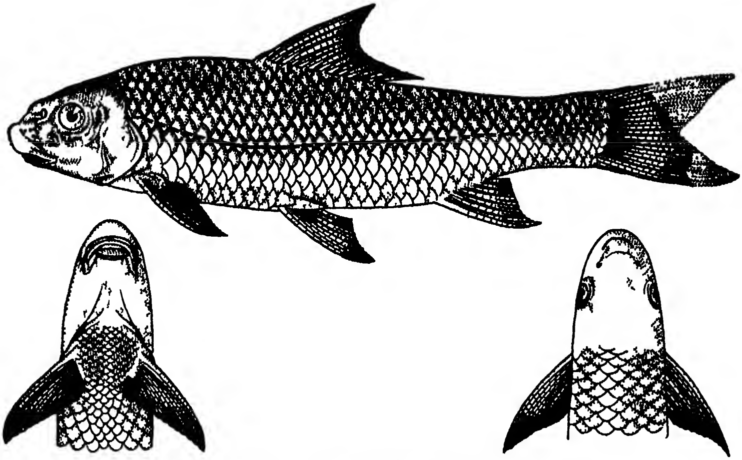
Size: Our longest 10½ inches.

Habitat: Streams and rivers of the Terai and Duars; in the hills only in the larger rivers. Day gives—'Along the Sind hills and Himalayas also in the Brahmaputra in Assam'.

Labeo dyocheilus (McClell.), *F.B.I.*, No. 303.

D. 2/11. P. 17. V. 9. A. 2/5. C. 19. L. 1. 43. **Barbels 1 pair.**

Note.—Five of our *Labeo* were identified as this species by the Indian Museum; we cannot distinguish them from young *L. pangusia*, but see Mukerji's note on the different races, *Bombay Nat. Hist. Soc. Journal*, XXXVII, 1st part (1934). A very variable species.



TEXT-FIG. 50.—*Labeo dyocheilus* (McClelland).

From Day's 'Fishes of India' the following appear to be the differences between the two species :—

L. dyocheilus.	*L. pangusia.*
P. 17. L. l. 43.	P. 15. L. l. 40–42.
Length of head $5\text{-}5\frac{1}{3}$, of caudal $5\frac{1}{3}$ in total length.	Length of head $5\frac{2}{3}\text{-}6$, of caudal $4\frac{1}{3}\text{-}5$ in total length.
Mouth wide, $2\text{-}2\frac{1}{3}$ in length of head.	Mouth narrow, $3\frac{3}{4}$ in length of head.
Sometimes depression across snout.	No depression across snout.
P. reaches V. and V. reaches base of A.	P. does not quite reach V. nor V. reach base of A.

Size: Our longest specimen 4·6 inches. Day says—'attains at least 3 ft. in length'.

Habitat: We do not know in which stream our specimens were obtained. Day gives—'Sind hills and along the Himalayas to Sikkim and Assam. It is common in Assam'.

Labeo gonius (Ham.), *F.B.I.*, No. 295.

Plate 2, fig. 11.

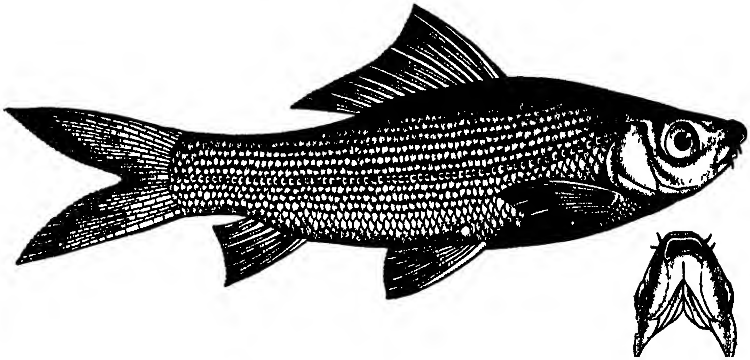
Bengali: *Kurchi* কুর্চী or *Goni* গণি.

D. 2-3/13-14. P. 17. V. 9. A. 2/5. C. 19. L. l. 71–84. Barbels 2 pairs.

Body not so deep as in *L. nandina* and *calbasu.* Snout prominent and with numerous pores but without a lateral lobe. Mouth narrow with extensible lips which are fringed. Length of head 5-5½, of caudal 5-5½, height of body 4-4½ in the total length.

Barbels : Minute.

Fins : Caudal deeply forked, both lobes pointed.



TEXT-FIG. 51.—*Labeo gonius* (Hamilton).

Colour : Greenish along the back becoming lighter on the sides. Scales with dark margins giving the effect of dark longitudinal lines, 'many (scales) having red lunules.' (*Day*)

Habitat : One specimen from South Borajhar forest (Eastern Duars), also exposed for sale in Siliguri bazaar. Day gives—'Indus in Sind, through the N.W. Provinces, Bengal, and Orissa to Ganjam, as low as the Kistna, Assam and Burma.'

Size : Our specimen 5·9 inches long. Day gives—'Up to nearly 5 feet in length.'

[**Labeo nandina** (Ham.)], *F.B.I.*, No. 290.

Plate 5, fig. 12.

Bengali : *Nandi* নন্দী.

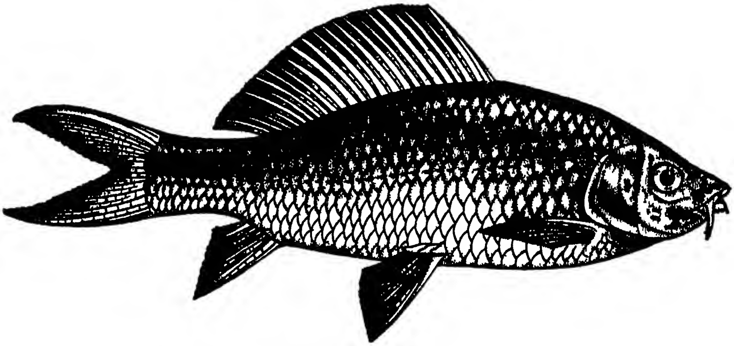
D. 2-3/22-24. P. 15. V. 9. A. 2/5. C. 19. L. 1. 42-44. Barbels 2 pairs.

A somewhat robust fish both profiles, but especially the dorsal, curved ; slightly concave above the eyes. Snout obtuse, projecting slightly beyond the jaws and having no lateral lobe. Width of mouth ½ length of head. 'Lips thick and fringed, with a distinct inner fold above and below.' (*Day.*) Length of head 4½-5, of caudal 4½-4½, height of body 3½ (4, *Day*) in the total length.

Barbels : Short.

Fins : Caudal deeply forked.

Colour: Dark greenish above becoming lighter below; many scattered scales orange-red. Day says—'A few cloudy blotches along the sides.' Iris red.



TEXT-FIG. 52.—*Labeo nandina* (Hamilton).

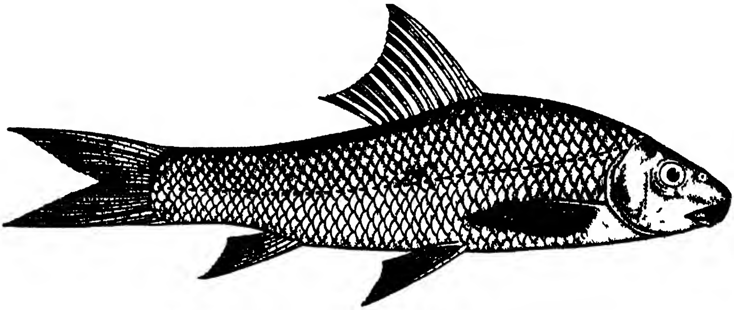
Size: Our specimen $7\frac{1}{2}$ inches.
Habitat: We have only found this fish exposed for sale in Siliguri bazaar. Day gives—'Bengal, Assam, and Burma.'

Labeo pangusia (Ham.), *F.B.I.*, No. 304.

Plate 2, fig. 6.

Bengali: *Utti* উটী; Nepalese: *Ter-mas* टेरमास, *Tera* टेरा, or *Dhenkara*(?) धेनकारा; Tharu: *Rewa* रेवा; Assamese: *Lasu*.

D. 2/11. P. 15. V. 9. A. 2/5. C. 19. L. 1. 40–42. Barbels 1 pair.



TEXT-FIG. 53.—*Labeo pangusia* (Hamilton).

Very like *L. dyocheilus* without the groove across the snout and with very distinct lateral lobes. The snout, too, is very obtuse with a large frontal area covered with pores above. Length of head $5\frac{1}{2}$-6, of caudal $4\frac{1}{2}$-5, height of body $4\frac{1}{4}$-$4\frac{3}{4}$ in the total length.

Barbels : Short, maxillary, concealed in labial fold.

Fins : Caudal deeply forked ; the lower fins in this species are slightly shorter than in *L. dyocheilus*.

Colour : Dull grey-green, lighter on the sides and beneath. Fins sometimes tinted red. 'Sometimes each scale has a dark mark.' (*Day*)

Size : Our longest 25½ inches.

Habitat : From the largest rivers to the smallest, clear-water, streams in the Duars and Terai. Day gives—'Himalayan range and generally through Sind, the Deccan, N.W. Provinces to Bengal, Cachar, and Assam.'

Habits : A large proportion of these fish in a poacher's catch is, we believe, an indication that dynamite has been used. This suggests that they remain at the bottom of deep pools where the effect of the charge might be supposed to be greatest.

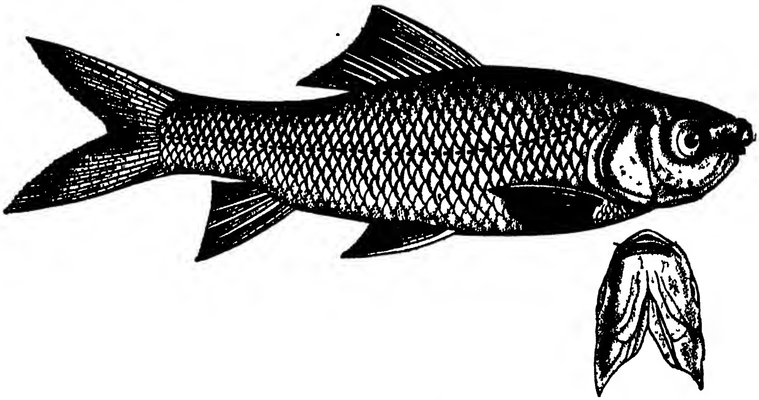
Labeo rohita (Ham.), *F.B.I.*, No. 297.

The Rohee.

Bengali : *Rui* রুই ; Hindi : *Rohu* রোহু.

D. 3/12-13. P. 17. V. 9. A. 2/5. C. 19. L. l. 40–42. Barbels one or two pairs according to Day ; none in ours.

Very like *L. nandina* in general appearance ; snout with no lateral lobe. Day gives—'Length of head 4½-5, of caudal 4½, height of body 4½ in the total length'.



TEXT-FIG. 54.—*Labeo rohita* (Hamilton).

Barbels : According to Day there is 'a short and thin maxillary pair. A rostral pair is said to be sometimes present'.

Fins : Caudal deeply forked.

Colour : 'Bluish or brownish along the back, becoming silvery on the sides and beneath.' (*Day*.) Ours were grey

above, scales with dark margins and red centre or sometimes orange buff inside a dark edging. Fins diffusely banded grey and red.

Size: The largest we have measured was 29½ inches long. Day says it attains three feet or more.

Habitat: Deep pools in clear sluggish streams (*e.g.* Bania River) such as occur towards the south of our area. Day gives—'Fresh-waters of Sind, and from the Punjab through India and Assam to Burma'. It is largely used to stock tanks.

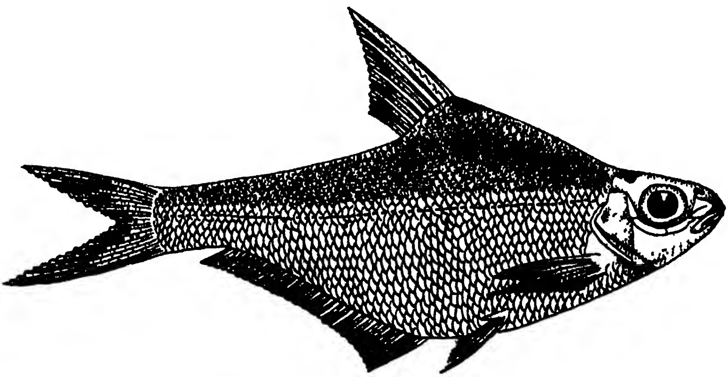
Habits: It is caught in tanks on rod and line and said to give good sport.

Rohtee cotio (Ham.), *F.B.I.*, No. 417.

Bengali: *Mauwa* মাউয়া; Hindi (Bihar): *Gurda* गुर्दी.

D. 11-12(3-4/8). P. 13. V. 10. A. 29–36(2-3/27–33). C. 19. L. l. 55–70. Barbels none or rudimentary.

'Profile over nape concave, from thence a great rise to the base of the dorsal fin, upper jaw slightly the longer.' (*Day*) Length of head 5½-6, height of body 3-3½ in total length.



TEXT-FIG. 55.—*Rohtee cotio* (Hamilton).

Colour: 'Silvery, darkest along the back and sometimes with a silvery lateral band. Some have a black blotch before the base of the dorsal fin, and another on the nape.' (*Day*)

Size: Day gives—'Attaining at least 6 inches.'

Habitat: We have only one specimen from our area—the Apalchand River in the Western Duars, but it is sometimes sold in Siliguri bazaar. Day gives—'From Sind throughout India (except the Malabar Coast and south of the Kistna) and Burma.'[1]

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[1] Mukerji notes that *R. cotio* is replaced in Burma by another species *R. duvaucelii*.

Semiplotus semiplotus (McClell.), *F.B.I.*, No. 326 ***Semiplotus macclellandi.***

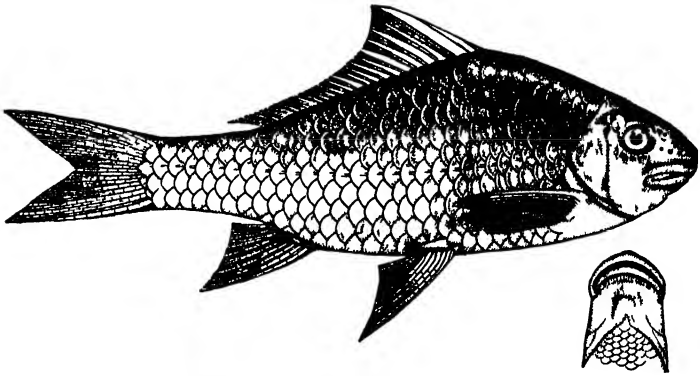
Plate 5, fig. 8.

Bengali (local): *Badangi* बाधांगी; Nepalese: *Chepti* चेपटी; Mechi: *Darangni.*

D. 3/24-25. P. 16. V. 10. A. 2/7. C. 19. L. 1. 27–33. Barbels nil.

Body deep but not much compressed laterally. Snout thick and prominent with a very distinctive row of open pores above the mouth. Mouth wide, inferior. Length of head $5\frac{1}{2}$-6, of caudal 4-$4\frac{1}{2}$, height of body $3\frac{1}{2}$-$3\frac{3}{4}$ in the total length.

Fins: The last undivided ray of dorsal strong and osseous, the first few branched rays much longer than the rest. Caudal deeply forked with pointed lobes.



TEXT-FIG. 56.—*Semiplotus semiplotus* (McClelland).

Colour: Dull silvery, darkest above. Fins yellowish, the lower ones sometimes tinted orange. When seen in the water there appears to be a dark mark at mid-body passing over the back but this is not visible out of water.

Size: We have taken them up to 9 inches in length but they are usually smaller. Day says they attain two feet.

Habitat: In all clear streams of the lower hills, Terai and Duars, particularly in moderately slow water where it is one of the commonest of our fishes. Day gives—'Rivers in Assam, especially in the upper portion of that district, but found as low as Goalpara; also Burma.'

Habits: Griffiths says that it refuses all baits and we have never known it taken on rod and line.

Group V.—THE CARPS WITHOUT LARGE SWIM-BLADDERS.

Psilorhynchus balitora (Ham.), *F.B.I.*, No. 278.

Plate 2, fig. 3.

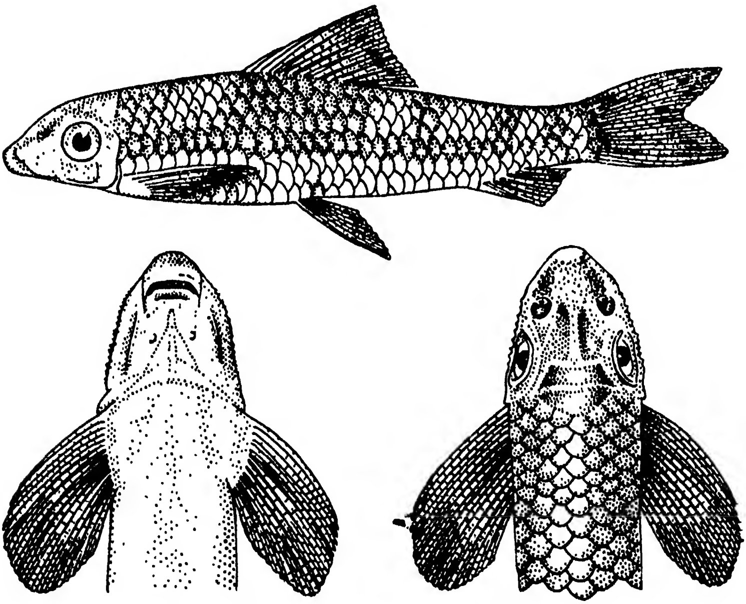
Hindi : *Titari* तितारी.

D. 2/7-8. P. 17. V. 9. A. 2/5. C. 18. L. l. 35. Barbels nil.

Back very much arched, under surface flattened, head somewhat depressed. 'Length of head $5\frac{1}{4}$, of caudal 5, height of body 5 in the total length.' (*Day*). But for the absence of barbels looks very like a young *Garra*.

Fins : Dorsal in advance of pelvics, pectorals and pelvics nearly horizontal, the outer 7 rays of the former and two of the latter unbranched.

Mouth : Small, below tip of snout.



TEXT-FIG. 57.—*Psilorhynchus balitora* (Hamilton).

Colour : Yellowish grey to brown ('reddish-brown', *Day*) with diffuse darker blotches.

Size : Our longest $2\frac{1}{2}$ inches.

Habitat : Streams of the Terai and Duars. Day gives—'Hill streams and rapids in N.E. Bengal and Assam.' This species has been recently recorded for the first time from Burma

by Mukerji [see *Journ. Bombay Nat. Hist. Soc.*, XXXVI, pp. 829–831 (1933)].

Psilorhynchus sucatio (Ham.).

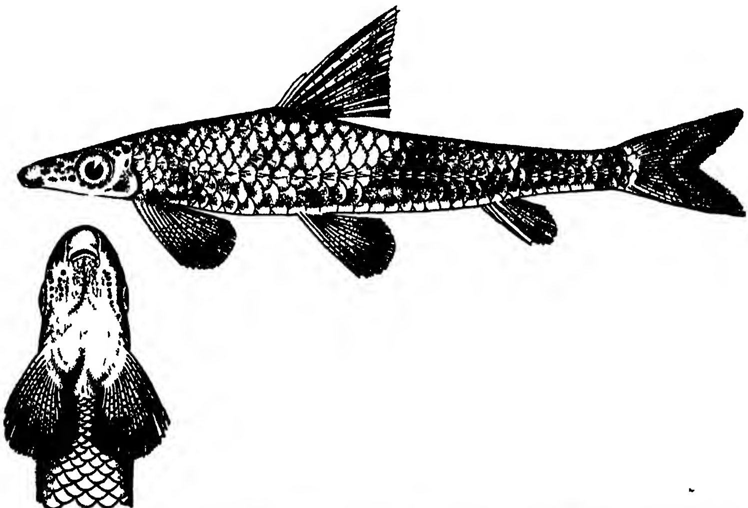
1822. *Cyprinus sucatio*, Hamilton, *Fish. Ganges*, pp. 347, 393.

Note.—This fish has been confused by Day with *Homaloptera bilineata* Blyth. See Mukerji's note in *Bombay Nat. Hist. Soc. Journal*, XXXVI, pp. 823–828 (1933).

D. 2/7–8. P. 4/9–10. V. 2/7–8. A. 2/5. L. l. 36–38. Barbels nil.

Head markedly depressed and spatulate, otherwise very like *P. balitora.* 'The length of the head is contained about 5 times in the length of the body excluding the caudal fin. The depth of the body....is contained 5½ times in the length of the body' (Hora, *Rec. Ind. Mus.*, Vol. XXII, p. 731, 1921). Eyes large, 3 diameters in length of head.

Fins : 'The dorsal fin commences in advance of the ventrals (*i.e.* pelvics) and its origin is much nearer the tip of the snout than to the base of the caudal fin.... The caudal fin is.... deeply forked. Both the lobes are pointed ; the upper is slightly longer than the lower.' (Hora, *op. cit.*) Paired fins horizontal.



TEXT-FIG. 58.—*Psilorhynchus sucatio* (Hamilton). (Copied from *Rec. Ind. Mus.*)

Colour : Light brown with irregular black blotches above and below the lateral line. Hamilton describes it as—'greenish, with scattered dots ; on the sides these are collected into clouds, and below the body is whitish and diaphanous.'

Hora (*op. cit.*) describing Annandale's and Shaw's specimens from the Mahanadi and Sivoke rivers writes—"five broad, clouded vertical bands on the body and a number of stripes on the caudal fin.' We have a note (by Shebbeare) on a fish from either the Sivoke or Gulma River—'Reddish-yellow. Each scale with two dark brown horizontal lines, scales below the lateral line with brown spots'.

Size : Our longest 3¼ inches.

Habitat : Clear rapid streams of the Terai (Mahanadi, Gulma, and Sivoke). Hamilton found this fish in 'the rivers of Northern Bengal.'

Balitora brucei Gray, *F.B.I.*, No. 275 ***Homaloptera brucei***, in part.

Note.—Under this name Day confused the species here described with a quite distinct fish from South India now called *Bhavania australis* (Jerdon).

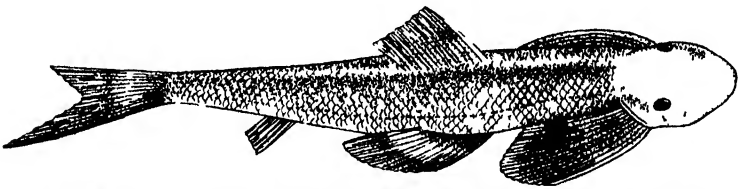
Nepalese : *Tita-kabri* तिता-काबरी.

D. 3/8. P. 9-10/12–11. V. 2/9. A. 2/5. C. 17. L. 1. 62–69(70 *Day*). Barbels 3 pairs.

Snout and anterior part of the body depressed, snout spatulate. 'Length of head 6½, of caudal 5 in the total length.' (*Day*)

Barbels : One pair maxillary and two pairs rostral, all very short. *Mouth* small, inferior.

Fins : Pectorals nearly reach pelvics ; lower lobe of caudal longer. '*Scales* absent from chest and as far as the posterior margin of the base of the ventrals (*i.e.* pelvics).' (*Day*)



TEXT-FIG. 59.—*Balitora brucei* Gray. (Copied from *Rec. Ind. Mus.*)

Colour : Brown blotched with a darker tint.

Size : Our longest 3½ inches.

Habitat : Our specimens are from the Mahanadi River (clear with sand and gravel). Day gives—'(Wynaad and Bowany Rivers in Madras),[1] Himalayas from about Darjeeling through Boutan, Assam, and the Khasia Hills.'

[Since Day's time *Balitora brucei* has been recorded from several localities in Burma and from the Chittagong Hill-Tracts.—*S. L. Hora*.]

[1] The words enclosed by us in brackets refer to the South Indian species, *Bhavania australis* (Jerdon).

Group VI.—THE LOACHES.

KEY TO THE FAMILY COBITIDÆ (LOACHES) IN THIS LIST.

A sharp, bony prickle beneath the eye in both sexes :—

Front of Dorsal nearer to snout than to base of Caudal or mid-way between them :—

Caudal deeply forked (lobed part as long as unlobed) :—

Caudal about twice as long as the height of its base ; about 7 oblique darker bands from back to belly and 3 bars across Caudal .. .. .. *Botia dario* (p. 65)

Base of Caudal about $1\frac{1}{2}$ times into its length ; body mottled with paler blotches or short transverse bands on a darker ground .. .. .. *Botia dayi* (p. 66)

Caudal not, or very shallowly, forked (lobed for less than $\frac{1}{4}$ of its length) :—

Profile elevated over the eyes, at which point body is deepest ; 6 or 7 dark blotches from snout to tail along lateral-line with less intense markings between this and the back.

Somileptes gongota (p. 78)

Body deepest about Dorsal :—

A broad dark band flanked by lighter ones along the lateral-line .. *Lepidocephalichthys guntea* (p. 68)

About 10 dark marks along lateral-line and 8 bars across the back, an intense dark spot at top of base of Caudal—

Lepidocephalichthys annandalei (p. 67)

Dorsal much nearer Caudal than the snout ; no markings—

Acanthophthalmus pangia (p. 65)

No bony prickle beneath the eye, though males may have a cartilaginous pad there :—

Vent much nearer end of Caudal than tip of snout—

Nemachilus spp. (for key, see p. 69)

Vent about mid-way between snout and end of Caudal—

Aborichthys elongatus (p. 63)

Aborichthys elongatus Hora.

1921. *Aborichthys elongatus*, Hora, *Rec. Ind. Mus.*, XXII, p. 735.

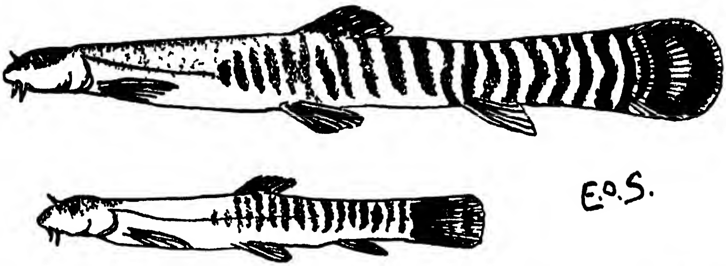
D. 2/6. P. 10. A. 2/5. C. 19. Barbels 3 pairs.

Body very much elongated, cylindrical in front and laterally compressed towards the tail. The dorsal and ventral profiles almost parallel. The vent is far forward, level with the posterior end of the pelvics. Length of head 6 (young) to $7\frac{3}{4}$ (adult), caudal $6\frac{1}{2}$ (young) to $7\frac{3}{4}$ (adult), and height of body 8 (young) to $9\frac{1}{2}$ (adult) in total length.

Barbels : A short erect pair over the nostrils, three pairs on the mouth.

Fins : Root of pelvics nearer to that of pectorals than of the anal. Caudal rounded, in larger specimens higher than the body.

Colour: Anterior third of the fish dusky above and pale beneath, the remainder pale with a series of about 20 dusky transverse bands approximately equal to the interspaces. These increase in length and depth of colour posteriorly; the first being no more than a spot in the region of the lateral line. At the dorsal fin they meet over the back and, at the anal, completely encircle the body. Some are confluent or forked. In smaller fish they are about 17 in number, begin further back, do not meet across the belly and are wider in proportion to the pale interspaces. Fins pale, the dorsal with two indistinct dusky bars. Caudal fin with concentric bands of the following colours (beginning from the posterior margin) pale, red, dusky red, dusky, pale, dusky. In smaller fish the whole caudal fin is reddish with three or four indistinct bands.



TEXT-FIG. 60.—*Aborichthys elongatus* Hora. (Copied from *Rec. Ind. Mus.*)

Size: Our longest 3¾ inches.

Habitat: Our specimens from the Riyang River (at 2,000 ft. elevation) and streams in the Terai.

Note:—This species is closely allied to *A. kempi* (described by Chaudhuri from the Abor and Garo hills and Upper Burma, *Rec. Ind. Mus.*, VIII, p. 245) to which some of our specimens were at first referred. It is distinguished on the following points (*Rec. Ind. Mus.*, XXII, p. 735, 1931):—

'*A. kempi*, Chaudhuri.	*A. elongatus*, Hora.
1. The snout is a little shorter than the post-orbital part of the head.	**1. The snout is almost equal to the post-orbital part of the head.**
2. There are 7 branched rays in the dorsal fin.	**2. There are only six branched rays in the dorsal fin.**
3. The dorsal is equidistant between the tubular nostrils and the root of the caudal.	**3. The dorsal is equidistant from the tip of the snout and the base of the caudal fin in the adult specimen; in younger specimens it is somewhat nearer to the tip of the snout than to the base of the caudal.'**

Acanthophthalmus pangia (Ham.), *F.B.I.*, Nos. 240 and 241
Apua fusca.

Note.—Some individuals of this species have, others have not, a pair of pelvic fins (see Hora in *Nature*, Sept. 20th, 1930, p. 435). Day allotted these two forms to separate Genera, *Acanthophthalmus* (with pelvics) and *Apua* (without pelvics).

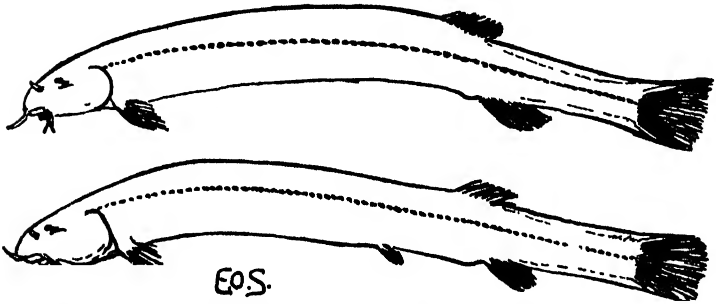
Bengali (according to Day) : *Pangya* পাংগ্যা.

D. 2/6. P. 10. V.[1] 6-7. A. 2/5. C. 17. Barbels 3 pairs.

Body elongate and laterally compressed. Eyes minute. An erectile, bifid, suborbital spine. 'Length of head $7\frac{1}{2}$-8, of caudal 8, height of body $7\frac{1}{2}$-8 in the total length.' (*Day*)

Barbels : One rostral and two maxillary pairs, the longest 2/5ths the length of the head.

Fins : Dorsal just in front of the anal ; caudal rounded.



TEXT-FIG. 61.—*Acanthophthalmus pangia* (Hamilton), without and with small pelvic fins.

Colour : Brownish-yellow without any markings.

Size : Our longest 1·6 inches ; Day gives $2\frac{1}{2}$ inches.

Habitat : Fairly common in the Sevoke River near its junction with the Tista. Day gives—'North-east Bengal, the northern portions of Pegu and Upper Burma.' He mentions a specimen from below Darjeeling collected by Mr. Mandelli.

Habits : In the Sevoke River Hora found the form without pelvics among the debris at the bottom of still pools and the form with pelvics in the swift water of pebbly runs. He therefore suggests that the two forms may be correlated with their habitats.

Botia dario (Ham.), *F.B.I.*, No. 230.

Mechi : *Balabotia.*

Note.—The *B. geto* of Hamilton proves to be a young of this species ; *B. geto* of Day is the next species.

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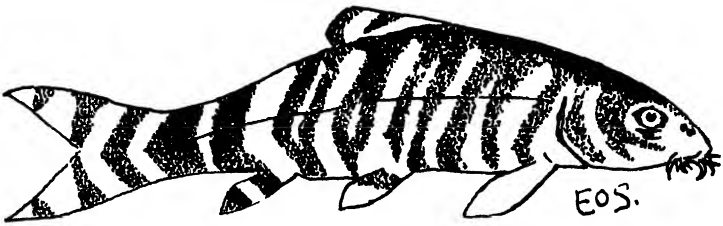
[1] Pelvics present or absent.

D. 3/9-10. P. 14. V. 8. A. 2/5–6. C. 19. Barbels 4 pairs.

The body is laterally compressed; in profile a typical loach though it tapers a little more towards the abruptly forked caudal fin than some other loaches. The back is sharply arched from the dorsal fin to the mouse-like head with short, downward-pointed barbels. A strong, bifid, backward curved spine is countersunk below each eye. The scales are minute and hardly noticeable. Length of head 4½-5, of caudal 5, height of body 5 in the total length. Eye 5 diameters in the length of the head.

Barbels: Four pairs, the longest hardly reaching the orbit, tapering.

Fins: The dorsal fin begins just before the pelvics.



TEXT-FIG. 62.—*Botia dario* (Hamilton).

Colour: The body is encircled by seven or more dark brown oblique bands almost straight separated by yellowish ones of about the same width. There are three more or less broken dark bands on the caudal fin.

Size: Our largest specimen is 3½ inches long.

Habitat: Hitherto we have only found this fish in the Singhimari stream (clear) and Chel River in the Apalchand forest (Western Duars). Day gives the distribution as Bengal, the N.W. Provinces, Assam, and Cachar.

Botia dayi Hora, *F.B.I.*, No. 231 *Botia geto*.

1932. *Botia dayi*, Hora, *Rec. Ind.* Mus., XXXIV, p. 571.

Nepalese: *Getu* गेटु or *Singhi* सिंघी.

Note.—This species is the *B. geto* described and figured in Day's *Fishes of India*, but the fish so named by Hamilton proves to be a young of *B. dario* (Ham.).

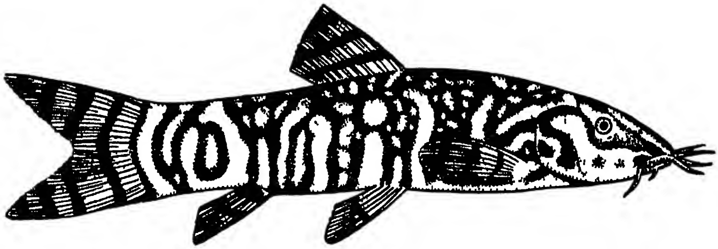
D. 3/9. P. 14. V. 8. A. 2/5. C. 19. Barbels 4 pairs.

The body is laterally compressed; in profile a typical loach tapering but little towards the abruptly forked caudal fin. The line of the belly is almost straight and the back arched sharply from the dorsal fin to the mouse-like head with short, downward-pointing barbels. A strong, bifid, backward-curved

spine is countersunk below the eye but 'as a rule not extending to below the posterior margin of the orbit.' (*Day*) Length of head 4½ (*Day* 5¼), of caudal 5, height of body 4½ (*Day* 5 to 5½) in the total length. Eye diameter 7 in the length of the head.

Barbels : Shorter than in *B. dario*.

Colour : Somewhat like *B. dario* but the bands are irregular and partly confluent enclosing variously sized roundish yellow and bluish blotches. Sometimes there are no lighter bands and the whole body is marbled with small blotches of the lighter colour. Pelvic fins with two, the other fins and each lobe of the sharply forked caudal with three dark cross-bands. Small fish are the darkest.



TEXT-FIG. 63.—*Botia dayi* Hora.

Size : Our largest specimen 4·8 inches long.

Habitat : Hitherto we have only found this fish in the Mahanadi. Day gives—'From Sind, through the Punjab, Himalayas, Valley of the Ganges, Jumna, Sone River, and Assam.'

Lepidocephalichthys annandalei Chaudhuri.

1912. *Lepidocephalichthys annandalei*, Chaudhuri, *Rec. Ind. Mus.*, VII, p. 442, pl. xl, figs. 3, 3a, 3b.

Bengali : *Poia* পোয়া.

D. 1/7. P. 7-8. V. 7. A. 1/6. C. about 24–26. Barbels ? pair.

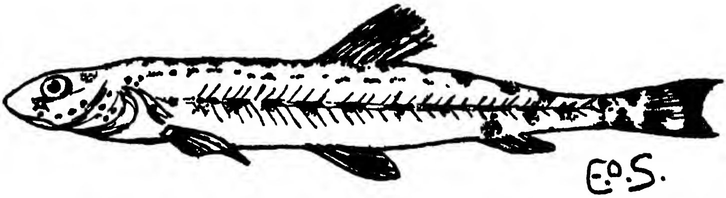
Body elongate and cylindrical. A preorbital bifid spine present. Length of head 6, caudal 5½, height of body 8 in the total length.

Barbels : Very minute, only the maxillary pair distinct.

Fins : Commencement of dorsal barely posterior to that of the pelvics ; hinder margin of caudal concave.

Colour : Very light brown on back, silvery on flanks and white beneath. On this brown colour is a pattern of minute dark brown specks. By their density or sparseness along the dorsal ridge they form a series of about eight very short transverse bars each about ⅓rd of the breadth of the interspace, below the dorsal ridge these specks are fewer and form an irregular wavy pattern above the lateral line and, along it, a series of about

11 short black dashes with equal interspaces. There are rather larger dark brown dots on the sides of the head and a distinct, more or less triangular, black spot surrounded by a yellow patch on the upper half of the root of caudal. There are several dark brown bands across dorsal and caudal.



TEXT-FIG. 64.—*Lepidocephalichthys annandalei* Chaudhuri.

Size: Our longest specimen was 1·5 inches, another 1·1 inches contained fully formed eggs and must therefore have been mature.

Habitat: Hitherto we have only found it in the Panchenai River near Matighara. Chaudhuri described the type specimen from 'Eastern Himalayas.'

Lepidocephalichthys guntea (Ham.), *F.B.I.*, No. 237.

Plate 2, fig. 2.

Bengali (local): *Poia* পোয়া, (South Bengal), *Gunte* গুঁতে; Rabha: *Na-mucha* or *Na-mochoṅ*; Chota Nagpuri: *Gitu* गीटू.

D. 2/6. P. 8. V. 7-8. A. 2/5. C. 16. Barbels 3 pairs.

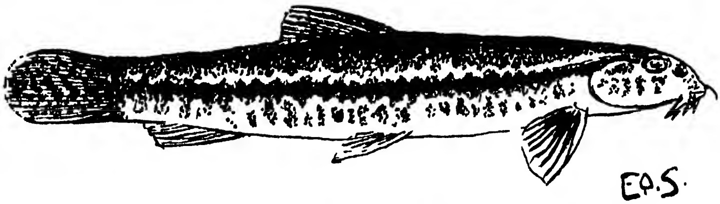
Lower profile of the snout horizontal, upper profile almost a quadrant. Upper and lower profiles of the body nearly parallel but body deepest in front of dorsal fin. A large erectile, bifid spine countersunk below the eye. Head partly scaled. Length of head 6 (*Day* 6½–6¾), caudal 6, height of body 6 (*Day* 5¾–6½) in the total length.

Barbels: Short, though longer than in *Somileptes*. 'A fleshy flap from the lower surface of the mandible on either side joins the maxillary barbel, and each has one or two barbels along its edge.' (*Day*)

Fins: Dorsal almost opposite pelvics; caudal entire ('generally' *Day*). *Scales* very minute.

Colour: The ground colour is dark brown on the dorsal ridge the rest being yellowish white with dark brown specks coalescing to form a pattern of darker and lighter longitudinal bands. The central one of these is darkest forming an almost black flank-stripe about ⅛th of depth of body and extending from the upper part of the gill opening to the root of caudal. This is flanked above and below by narrower light stripes and these again by interrupted brown bands the upper one darkening

into the brown of the dorsal ridge and the lower fading into the white of the belly. The edges of all bands are wavy and the fainter ones interrupted so as to suggest an indistinct transverse pattern in a series of about 25. The specks coalesce to form five pale-brown patches on the head and a vertical dark bar across the base of caudal. This bar is darkest at its upper end, sometimes approximating to a spot. The fins are yellowish, dorsal and caudal with a speckled pattern, that on the latter suggesting a continuation of the flank-stripe. We have not obtained any specimen with the pattern represented in Day's figure.



TEXT-FIG. 65.—*Lepidocephalichthys guntea* (Hamilton).

Habitat: Gravelly or muddy streams and tanks in the Terai and Duars. Day gives—'Punjab, throughout India (except Mysore and south of the Kistna, and also the Malabar Coast). I have them from Darjeeling, and several localities on the Himalayas.' (*Day*)

KEY TO GENUS NEMACHILUS IN THIS LIST.

(From Dr. Hora's paper in the *Records of Indian Museum*, XXXVII.)

About 14 branched rays in Dorsal. (Body irregularly blotched; Caudal entire or slightly emarginate) .. .. *N. botia* (p. 71)

Not more than 8 branched rays in Dorsal:—

Body without vertical bands:—

Body with one or two longitudinal series of spots *N. corica* (p. 72)

Dorsal surface and sides with a uniform dull grey colour— *N. shebbearei* (p. 77)

Body with vertical bands:—

Lateral line incomplete:—

Caudal without bands; vertical bands few, broad and saddle-shaped, not extending to ventral surface *N. devdevi* (p. 72)

Caudal with 4 or more bands; body encircled by a number of bands .. .. *N. multifasciatus* (p. 73)

Lateral line complete:—

Dorsal surface and sides dark with narrow yellowish bands— *N. savona* (p. 75)

Dorsal surface and sides pale-olivaceous with dark, vertical bands separated by broad yellowish interspaces:—

Well-marked nasal barbels—*N. rupicola* var. *inglisi* (p. 74)

Nasal flaps not produced into barbels :—

Dorsal and Caudal marked with numerous, irregular, narrow bands .. *N. multifasciatus* (p. 73)

Dorsal with or without a row of spots; Caudal with or without 1–3 V-shaped fairly broad markings :—

Body with a few broad and bold bands encircling it; a broad black band at base of Caudal; Ventrals extending to anal opening .. *N. beavani* (p. 70)

Body with narrow, incomplete bands not extending to ventral surface; a narrow, black bar at base of Caudal; Ventrals not extending to anal opening— *N. scaturigina* (p. 76)

In the above key *N. multifasciatus* is given in two places as it may have a complete or incomplete lateral line.

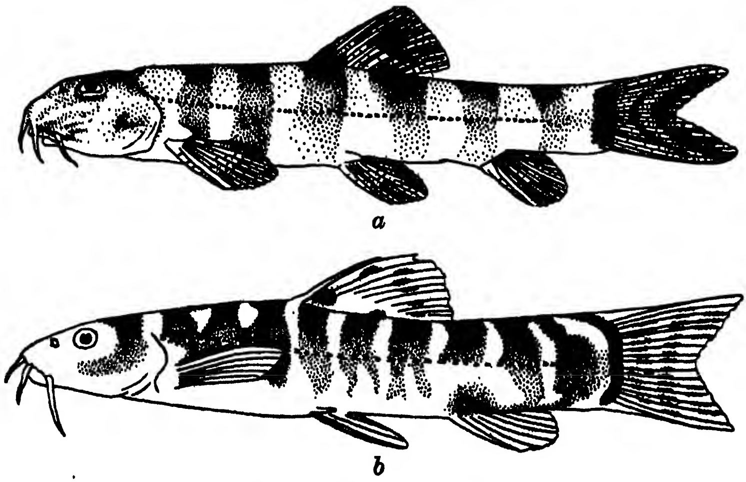
[Since the revision of the Eastern Himalayan species of *Nemachilus*, considerable fresh material became available from the Naga Hills, Assam. The range and specific limits of some of the species listed in the above key had to be revised. For the purpose of this paper, however, the treatment of the species as given below will be quite helpful to the readers.—*S. L. Hora.*]

Nemachilus beavani Günther.

1868. *Nemachilus beavani*, Günther, *Cat. Fish. Brit. Mus.*, VII, p. 350.

Not the *N. beavani* of Day, *Journ. Linn. Soc.* (*Zool.*), XI, p. 529 (1873).

D. 2/8. P. 10. V. 8. A. 2/5. C. 19.



TEXT-FIG. 66.—*Nemachilus beavani* Günther. (Copied from *Rec. Ind. Mus.*)

a.—Sketch of type-specimen in British Museum.

b.—Sketch of fresh-specimen from Darjeeling-Himalayas.

This fish has a shape peculiar to some loaches that is to say, when viewed from above, it tapers smartly from the gills to the

tail but, when viewed from the side, it tapers gradually from the base of the caudal fin towards the snout. Hora notes that specimens taken in fast-flowing streams have a well-developed fleshy appendage in the axil of the pectoral fin.

Fins : The caudal fin is distinctly lobed. The pelvic fins are provided with fleshy appendages also.

Colour : The ground colour is yellowish with 7 transverse brown belts which are wider than the interspaces between them. These belts are continuous over the back and those in front of the dorsal fin are sometimes broken up to form numerous narrow bands. There is, in addition to the belts mentioned, a conspicuous dark band at the base of the caudal fin.

Size : Our longest was 1⅜ inches.

Habitat : Common in small streams at the foot of the hills.

Nemachilus botia (Ham.), *F.B.I.*, No. 247.

Plate 2, fig. 1.

Hindi (in Bihar) *Natwa* नटवा.

D. 2/10–12. P. 11. V. 8. A. 2/5. C. 17. Barbels 3 pairs.

A strongly built fish not unlike *Botia dario* in shape but somewhat broader towards the head. Below the eyes, where the prickles occur in *B. dario*, there are similar cartilaginous, but not bony, processes in the males of this species.

Fins : The caudal fin is slightly but distinctly lobed.

TEXT-FIG. 67.—*Nemachilus botia* (Hamilton).

Colour : The colouring of this species bears a resemblance to that of *Somileptes gongota*. It is mottled from the dorsal ridge to the lateral line which is marked by a darker longitudinal band having 9 or 10 downward projections which alternate with a series of blotches below the lateral line. The dorsal fin is speckled and the caudal has similar speckles arranged in wavy, but more or less vertical, lines. It appears to be a variable species.

Size : Our longest is just over 3 inches.
Habitat : Clear streams of the Terai and Duars.

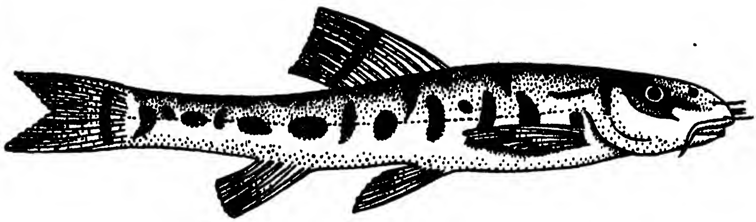
Nemachilus corica (Ham.), *F.B.I.*, No. 253.

This fish is recorded from the N.E. Bengal but we have never found it. We give Day's description of it verbatim :—

'Bengali : *Khorika* খরিকা .

'D. 10(2/8), P. 13. V. 8. A. 7(2/5). C. 17.

'Length of head $5\frac{1}{2}$ in the total length. *Eyes* in the middle 'of the length of the head. *Barbels*—thin, the external rostral 'pair longer than the orbit. *Fins*—the dorsal commences 'anterior to the vertral (*i.e.* the pelvics) and nearer to the snout



TEXT-FIG. 68.—*Nemachilus corica* (Hamilton).

'than to the base of the caudal, which last is lobed in its 'posterior half. *Scales*—visible in the posterior half of the body. '*Colour*—bluish, with about thirteen black blotches along the 'middle of the side, and smaller ones above and descending to 'between them ; usually a silvery band along the middle of the 'side.

'*Habitat*, N.E. Bengal—Punjab, and Assam.'

Nemachilus devdevi Hora.

1935. *Nemachilus devdevi*, Hora, *Rec. Ind. Mus.*, XXXVII, p. 54, pl. iii, figs. 5, 6.

D. 2/8. P. 10. V. 6–8. A. 2/5. C. 16.

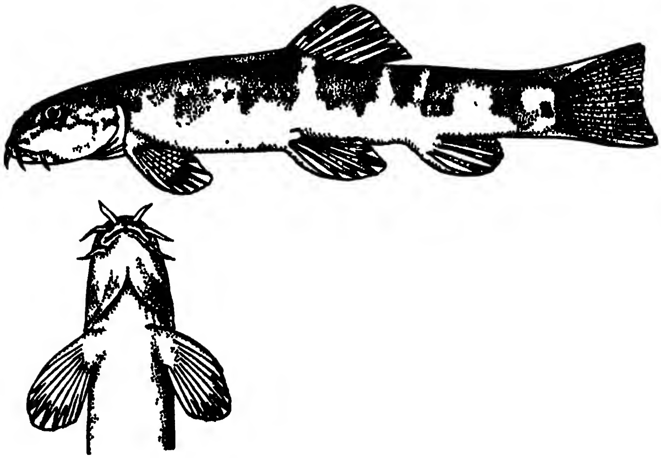
A slender little fish. The upper profile is slightly arched and the lower profile straight.

Scales : There are some very indistinct scales embedded in the skin.

Fins : The pelvic fins possesses a well-developed appendage in the axil.

Colour : The ground colour is yellowish with 7 to 9 brown belts which are much wider than the interspaces between them.

They are continuous over the back but only reach to just below the lateral line on the sides, where their ends are rounded off There is usually a deep black spot or short bar at the base of the caudal fin.



TEXT-FIG. 69.—*Nemachilus devdevi* Hora. (Copied from *Rec. Ind. Mus.*)

Size: Our longest was nearly 1¾ inches.
Habitat: Small streams at the foot of the hills

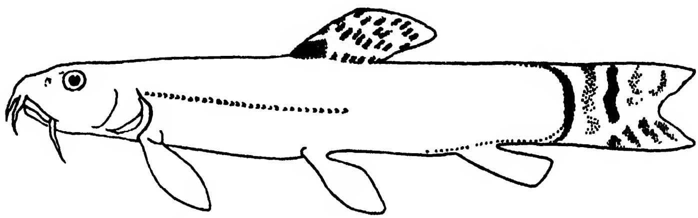
Nemachilus multifasciatus Day, *F.B.I.*, No. 257

D. 2/8. P. 11. V. 9. A. 2/5. C. 18. Barbels 3 pairs.

This fish was described by Day from 'Darjeeling and Assam' but has never been collected from these places since. Hora notes (*Rec. Ind. Mus.*, XXXVII, 1935) that the Siamese and Burmese specimens recorded under this name by Vinciguerre and Mukerji (vide *Journ. Bombay Nat. Hist. Soc.*, 15th Dec., 1933) are not the same species and he proposes the name *N. vinciguerrai* for them. Day describes the lateral line as complete but Hora notes that in Day's Assam specimen, in the British Museum, it only reaches the line of the ventrals and his Darjeeling specimen, in the Indian Museum, is in poor condition.

Colour: Day gives—'Vertical bands, as wide as the 'ground colour, pass from the back to the lower surface of the 'abdomen; those between the head and the dorsal fin are 'numerous, while there are about five posterior to the latter: 'in some examples the anterior bands coalesce. A dark band 'at the base of the caudal and dark marks on the head radiating

'from the eye. Fins yellow, the dorsal with four bands of spots 'and an equal number or more on the caudal. Ventral and anal 'with two bands each.' Hora notes (*op. cit.*)—'The chief dis- 'tinguishing feature of *N. multifasciatus* lies in the fact that the 'dorsal and caudal fins are provided with many rows of spots 'which are sometimes irregularly distributed. The only other



TEXT-FIG. 70.—*Nemachilus multifasciatus* Day. (Copied from *Rec. Ind. Mus.*)

'species which shows this character is Day's *savona* for which 'I have proposed the name *dayi*. The two species can be readily 'distinguished by the colouration of the body—narrow, yellowish 'interspaces between the bands in *dayi* and wide, pale interspaces 'between the bands in *multifasciatus*.'

Nemachilus rupicola var. inglisi Hora, *F.B.I.*, No. 254 (in part).

1935. *Nemachilus rupicola* var. *inglisi*, Hora, *Rec. Ind. Mus.*, XXXVII, p. 58, pl. iii, figs. 9, 10.

D. 2/7. P. 12. V. 8. A. 1/5. C. 16. Barbels 3 pairs.

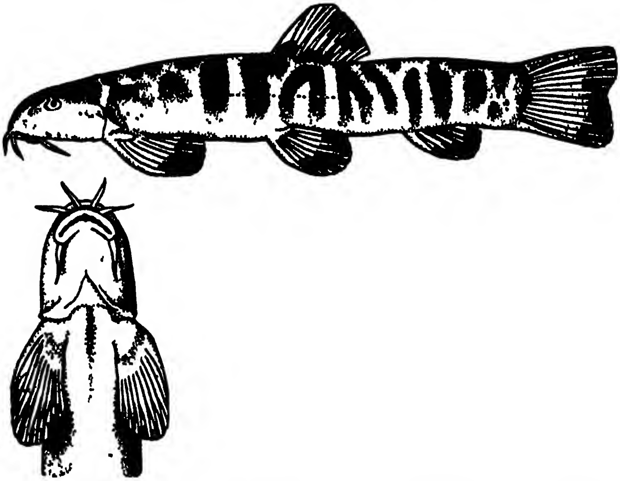
Hora distinguishes this variety from the typical *N. rupicola* of the Western Himalayas by its more strongly developed nasal barbels and the position and structure of the paired fins, the outer rays of which are provided with adhesive pads on the under-surface—apparently an adaptation for life in rapid currents. A stoutly built little fish, roughly cylindrical in front, except for the flattened belly, and tapering towards the tail which is slightly flattened in the vertical plane. The dorsal profile is slightly arched and the ventral straight.

Fins: The paired fins are horizontal; the caudal square or faintly lobed.

Scales: There are indistinct scales embedded in the skin on the upper surface; none on the lower.

Colour: The ground colour is yellowish with 14 to 16 brown transverse belts, rather wider than the interspaces between

them. These encircle the whole of the body from the gills to the caudal fin. Those behind the dorsal fin are almost continuous across the back but those in front of it break up into isolated blotches on the fore part of the back. The top of the head is closely mottled with finer blotches. The young lack the belts.



TEXT-FIG. 71 —*Nemachilus rupicola* var. *inglisi* Hora (Copied from *Rec. Ind. Mus.*)

Size : Our largest was nearly 3 inches.
Habitat : Streams at the foot of the hills.

Nemachilus savona (Ham.).

1935. *Nemachilus savona*, Hora, *Rec. Ind. Mus.*, XXXVII, p. 56, pl. iii, figs. 3, 4.

Not the *N. savona* of Day, for which Hora has proposed the name *N. dayi*.

D. 3/8. P. 9. V. 7. A. 2/5. C. 20. Barbels 3 pairs.

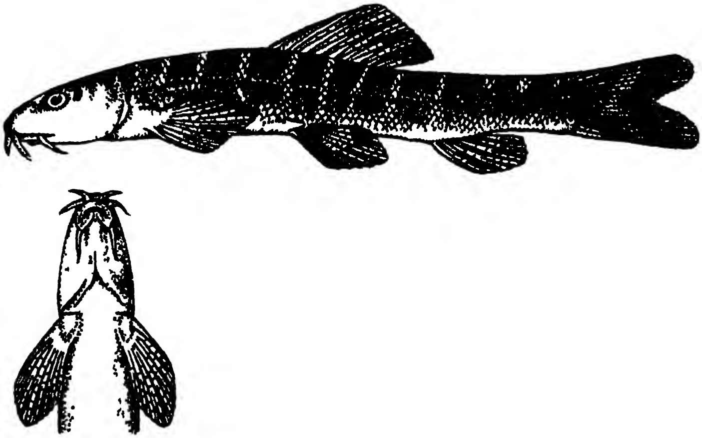
A slender little fish pointed at both ends. The upper profile is slightly arched and the lower profile straight. The belly is slightly flattened.

Fins : The paired fins are fan-shaped, horizontal and pointed in the middle.

Colour : There are 9 or 10 dark brown belts in this species which are considerably wider than the interspaces between them and obliterate them in some places. The dark belts meet under

the tail and some of them are forked where they pass over the back. The head is dark above and pale with some dark dots beneath There is a vertical black mark at the base of the caudal fin. In some specimens there are one or two V-shaped bands on the caudal fin.

Size : Our longest was just over 1¼ inches.



TEXT-FIG. 72.—*Nemachilus savona* (Hamilton) (Copied from *Rec Ind. Mus.*)

Habitat: Common at Sevoke and Siliguri in small clear streams Hamilton obtained the specimens from which he described the species in the Kosi at Nathpur in the extreme north-east of the Bhagalpur District close to the Purnea boundary.

Nemachilus scaturigina (McClell).

1935. *Nemachilus scaturigina*, Hora, *Rec. Ind. Mus.*, XXXVII, p. 64, pl. III, figs. 7, 8.

D. 2/7. P. 10. V. 8. A. 2/5. C. 19. Barbels 3 pairs.

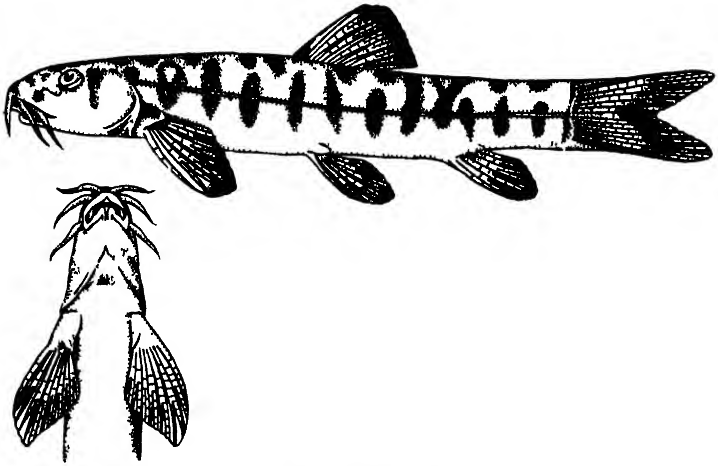
A more slender fish than *N. rupicola* and with a more pointed snout.

Fins : The caudal fin is square or slightly lobed.

Scales : Inconspicuous scales, embedded in the skin, are mostly on the hinder end of the body and only on the under surface.

Colour : The ground colour is yellowish with 9–12 transverse brown belts but, unlike those in *N. rupicola*, some of these

pass unbroken across the back and none of them reach the belly; the belts in this species are definitely narrower than the interspaces between them and the brown colour is paler than in *N. rupicola*, and sometimes some of the belts are reduced to isolated blotches. There is a black spot at the base of the first ray of the dorsal fin.



TEXT-FIG. 73.—*Nemachilus scaturigina* (McClelland). (Copied from *Rec. Ind. Mus.*)

Size: Our longest was just over 2 inches.

Habitat: Small streams near the foot of the hills. It is not very common.

Nemachilus shebbearei Hora.

1935. *Nemachilus shebbearei*, Hora, *Rec. Ind. Mus.*, XXXVII, p. 52, pl. iii, figs. 1, 2.

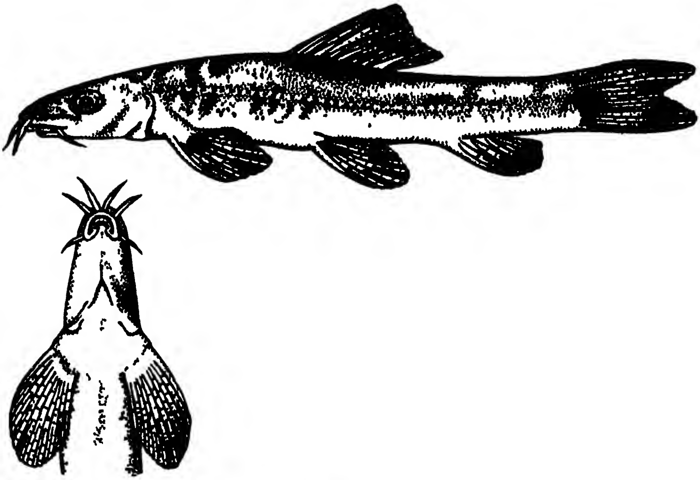
D. 2/8. P. 10. V. 8. A. 1/6. C. 18. Barbels 3 pairs.

The body is low and the head long and pointed; the upper profile is arched and the lower profile straight. The belly is flattened. In general appearance this fish resembles *Homaloptera bilineata* or *H. modesta*.

There is a bony process below the anterior border of the eye, a characteristic feature of the males of several species of *Nemachilus*.

Colour: Dull black on the back and sides, with faint indications of colour bands in places; pale olivaceous beneath.

Size : The solitary specimen known of this species at present measures just over $1\frac{3}{4}$ inches.



TEXT-FIG. 74.—*Nemachilus shebbearei* Hora. (Copied from *Rec. Ind. Mus.*)

Habitat : The specimen was found by Dr. Hora among a large collection of fish sent by us to the Indian Museum from the Terai and Duars and, unfortunately, there was no note of its origin.

Somileptes gongota (Ham.), *F.B.I.*, No. 236.

Bengali: *Ghor-poia* ঘরপোয়া (a name also applied to *Garra gotyla*) ; Mechi : *Mushra.*

D. 3/8. P. 1/10. V. 2/6. A. 2/5. C. 16. Barbels 3 pairs

The upper profile of the snout is straight or slightly concave rising abruptly to above the eyes which are close together near the top of the head. From this point the body tapers gradually to the peduncle of the tail. There is a small bifid suborbital spine reaching to below the middle of the orbit. Length of head $5\frac{1}{4}$, height of body 7-$7\frac{1}{2}$ in the total length.

Barbels : One small erect pair above the nostrils (not described or figured by Day) besides the pair at the sides of the snout and the maxillary pair.

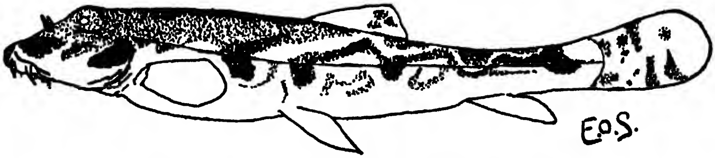
Fins : The dorsal fin begins ' opposite the root of the inner ventral (i.e. pelvic) ray '. (*Day*) Caudal entire.

Scales : Minute.

Colour : Light brown speckled with darker above, yellowish or whitish beneath. A variable pattern along the sides usually consisting of a series of about five large brown blotches with

light edges sometimes connected with oblique dark stripes or interspersed with smaller dark blotches. Two dark patches on each cheek. Fins yellowish, dorsal and caudal with dark spots arranged more or less regularly in transverse rows.

Size: Our largest is recorded as 3·9 inches long, but Shaw notes that we have had them larger.



TEXT-FIG. 75.—*Somileptes gongota* (Hamilton).

Habitat: Gravelly and muddy streams in the Terai and Duars. Day gives—'Assam, Bheer Bhoom, and Khasia hills.'

See D. D. Mukerji's note on this species, ***Rec. Ind. Mus.***, XXXIV, pp. 125–129 (1932).

Group VII.—THE CAT-FISHES.

KEY TO SUB-ORDER SILUROIDEA (CAT-FISHES) IN THIS LIST.

No spine in Dorsal; no adipose fin; Anal of 45 rays or more :—

Four pairs of barbels :—

Family CLARIIDÆ.

Dorsal long (over 60 rays)	..	*Clarias batrachus* (p. 80)
Dorsal short (6 or 7 rays)	..	*Heteropneustes fossilis* (p. 81

Two pairs of barbels; Dorsal absent or short (6 rays or less).

Family SILURIDÆ.

Eye above level of mouth :—

Caudal not forked	..	*Silurus cochinchinensis* (p. 84)
Caudal forked ..	..	.. *Wallago attu* (p. 84)

Eye behind angle of mouth :—

Longest barbels reach Pelvics—	*Callichrous bimaculatus* (p. 82)
Longest barbels reach Pectorals	*Callichrous pabda* (p. 83)

A spine in Dorsal. *Note* :—In most genera this is bony and unmistakeable; in *Sisor*, *Pseudecheneis*, *Euchiloglanis*, and *Olyra* it is weak but, in these 4 genera the Anal is short (less than 20 rays) and there is an adipose fin, two points which separate them from genera with no spine in Dorsal :—

A continuous margin of fin above, below, and round the end of the tail :—

Family CHACIDÆ.

One species only	..	..	*Chaca chaca* (p. 85)

Caudal at the end of the tail only :—

Anal long (28 rays or more); Adipose small or absent :—

Family SCHILBEIDÆ.

Four pairs of barbels :—

Dorsal much in advance of Pelvics :—

Longest barbels reach Pectorals—

Pseudeutropius murius (p. 88)

Longest barbels reach Pelvics .. .. *P. garua* (p. 87)

Dorsal practically opposite Pelvics—*Eutropiichthys vacha* (p. 86)

One pair minute barbels .. *Silonia silondia* (p. 89)

Two pairs of barbels :—

Family PANGASIIDÆ.

One species only .. *Pangasius pangasius* (p. 86)

Anal short (less than 20 rays) ; Adipose well developed :—

Two nostrils (one behind the other on each side) close together with a barbel between them :—

Family SISORIDÆ (for key, see p. 96).

Two nostrils (on each side) far apart, a barbel near the hindmost :—

Teeth on the palate as well as in the jaws :—

Family BAGRIDÆ (for key, see p. 89).

Teeth in the jaws but not on the palate :—

Family AMBLYCEPIDÆ.

One species only .. *Amblyceps mangois* (p. 95)

Clarias batrachus (Linn.), *F.B.I.*, No. 121 *Clarias magur.*

Plate 3, fig. 10.

Bengali : *Magur* মাগুর.

D. 62–76. P. 1/8–11. V. 6. A. 45–58. C. 15–17. Barbels 4 pairs.

Head vertically and tail laterally compressed. It is distinguished from all our other cat-fish by having a long (many-rayed) dorsal fin. Length of head 5½-6, of caudal 8¾-9, height of body 6½-7½ in the total length.

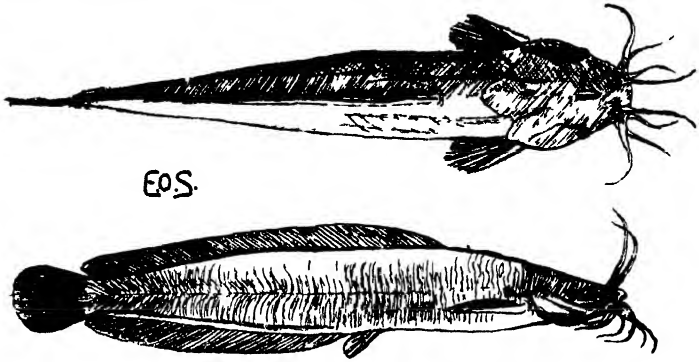
Barbels : The longest (maxillary) reaching base of pectorals.

Fins : Pectoral spine finely serrated but covered with skin. Caudal rounded.

Colour : Either a uniform rich reddish-brown or a uniform greyish-black. Fish of both colours are found together, no intermediate shades occur and, as far as we know, there is no other difference between them. There are one or more concentric arcs of a deeper shade on the caudal, where there are more than one that nearer the base is more distinct.

Size : Our longest 11 inches. Day says—' attains a foot and a half'.

Habitat : Terai and Duars ; usually in mud. Day gives—'Fresh and brackish waters of the plains of India, Burma, Ceylon, and the Malay Archipelago.'



TEXT-FIG. 76.—*Clarias batrachus* (Linn.).

Habits : Being able to breathe air, it can survive for a long time out of water.

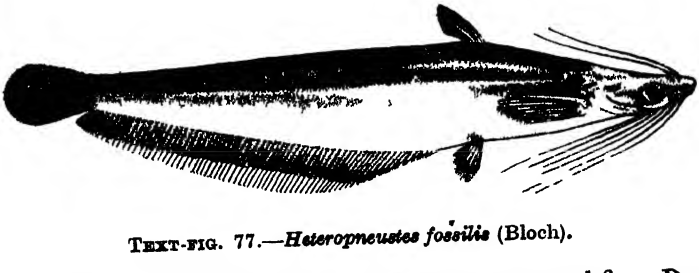
Heteropneustes fossilis (Bloch.), *F.B.I.*, No. 133 *Saccobranchus fossilis*.

Plate 3, fig. 9.

Bengali : *Singhi* শিঙ্গি.

D. 6-7. P. 1/7. V. 6. A. 60–79. C. 19. Barbels 4 pairs.

Head flat and rather wide ; the snout almost chisel-like. The body tapers uniformly in the horizontal plane from the gills to the caudal fin. In the vertical plane the back is almost a straight line from snout to tail while the ventral outline is bowed ;



TEXT-FIG. 77.—*Heteropneustes fossilis* (Bloch).

this effect is heightened by the shape of the long anal fin. Day gives :—'Length of head from 5½–7, of caudal from about 9–14, height of body (greatly depending upon food or season) from 5–8 in the total length.'

6

Barbels : Maxillary pair reach the pectorals or further.

Fins : The sharp, serrate pectoral spines are reputed to be poisonous and broken off by fishermen. Caudal rounded.

Colour : Dark purplish-brown, almost black, the young reddish-brown. Day says there are sometimes two longitudinal yellowish bands ; we have not seen these.

Size : We have taken them up to about 9 inches long. Day says they attain a foot or more.

Habitat : Rivers and tanks in the Terai and Duars—usually in mud. Day gives—' Fresh waters of Sind, India, Ceylon, Burma, and Cochin China.'

Day says the eggs are pea-green.

[**Callichrous bimaculatus** (Bloch)], *F.B.I.*, No. 138.

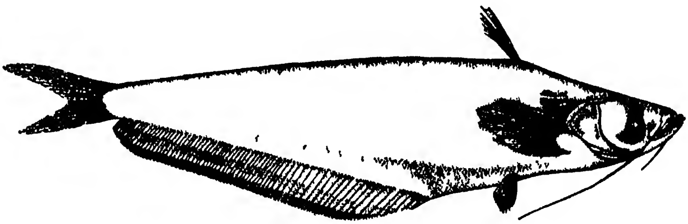
Hindi (Bihar) : *Chechera* चेचरा.

D 4. P. 1/13. V. 8. A. 2-3/58–72. C. 17. Barbels 2 pairs.

Body elongate and laterally compressed. Very like *C. pabda*, the chief distinctions being the shape of the caudal fins and the length of the barbels. Day gives—' Length of head 5–7, of caudal $6\frac{2}{3}$–7, height of body $5\frac{1}{3}$–$5\frac{1}{2}$ in the total length.'

Barbels : The longest pair (maxillary) reach the ventral.

Fins : Caudal forked, the lobes sharply pointed.



TEXT-FIG. 78.—*Callichrous bimaculatus* (Bloch).

Colour : We have not seen a live specimen. Day says—' Silvery shot with purple, a black spot on the shoulder behind the gill-opening and above the middle of the pectoral fin ; in some specimens this black spot is much better defined than in others.[1] Occasionally the caudal fin is tipped with black.'

Size : Our only specimen is 5·7 inches long. Day says they attain at least a foot and a half in length.

Habitat : We have only seen this fish in Siliguri bazaar. Day gives—' The fresh waters of Sind, and from the Punjab throughout India, Ceylon, and Assam to the Malay Archipelago

[1] *Note.*—Our notes say : silvery with *two* black spots behind gill-opening ; sometimes faint.

and beyond. Sometimes observed in Burma, according to Col. Tickell, within tidal influence.'

Callichrous pabda Ham., *F.B.I.*, No. 142.

Plate 3, fig. 7.

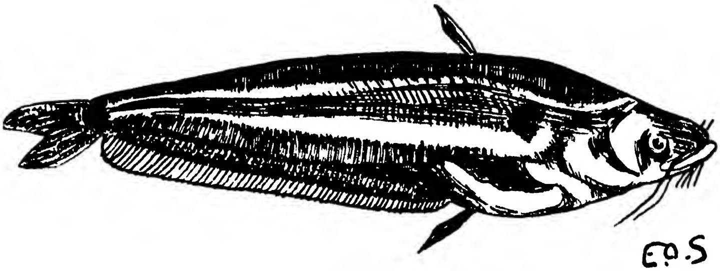
Bengali: *Pabda* পাব্দা; Mechi: *Tapugulinda.*

D. 4-5. P. 1/11–13. V. 8. A. 3/52–58. C. 18. Barbels 2 pairs.

Whole body laterally compressed, dorsal outline only slightly humped, ventral outline distinctly bowed. The belly, which is situated far forward, is usually distended and bulges downwards. Length of head $4\frac{1}{2}$-$5\frac{3}{4}$, of caudal $7\frac{1}{2}$-8, height of body $4\frac{1}{2}$-$5\frac{3}{4}$.

Barbels: The longest (maxillary) pair do not reach beyond the end of the pectorals.

Fins: Caudal forked, both lobes rounded or arching rather than tapering to a point. The whole fin directed slightly downwards. The pectoral spine may be serrated or smooth. (*Day*)



TEXT-FIG. 79.—*Callichrous pabda* Hamilton.

Colour: Variable; the general colour is silvery grey, darkest on the back and fading to white on the belly. In some there are two longitudinal lighter bands one above and one below the lateral line; in others there are confused blotches of light brown, darkest on the back. In all there is a dark oval shoulder-spot about half the length of the pectoral and situated just above the middle of this fin on the lateral line. In some there is another more diffuse spot near the base of the caudal. In life this fish has a very beautiful iridescence being shot with turquoise and mauve on a wide band along the lateral line and with green and gold on the opercle.

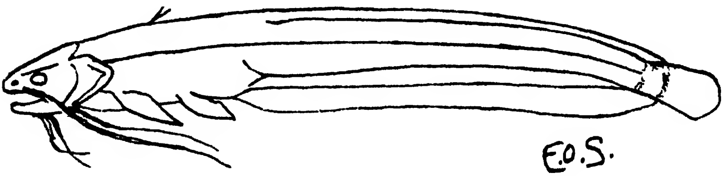
Size: Our longest 4·7 inches.

Habitat: Clear streams as well as muddy pools in the Terai and Duars. Day gives the Indus, Ganges, and Brahmaputra as well as Orissa and Darjeeling. Highly esteemed as food, especially for invalids.

Silurus cochinchinensis Cuv. and Val., *F.B.I.*, No. 126 *Silurus afghana* and 127.

D. 2. P. 1/13-14. V. 10. A. 70–78. C. 19. Barbels 2 pairs.

Fins : Dorsal rudimentary—consisting of two tiny bristles only. Anal and caudal scarcely united.



TEXT-FIG. 80.—*Silurus cochinchinensis* Cuvier and Valenciennes.

Colour : Purplish brown with traces of dark longitudinal lines.

Size : Our longest 5·7 inches. Day gives 7·2 inches.

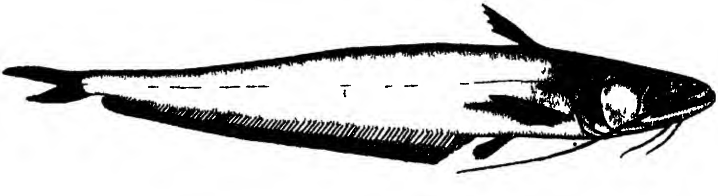
Habitat : Our only specimens were from the Western Duars. Day gives—' Himalayas ', his only certainly established locality being ' Darjeeling '. He cites two other sets of specimens both of which, unfortunately, are doubtfully located, one being either from Afghanistan or the Khasi Hills and the other either from Kashmir or Assam.

Wallago attu (Bloch), *F.B.I.*, No. 134.

Plate 3, fig. 5.

Bengali : *Boal(i)* বোয়াল or বোয়ালি ; Hindi : *Bowali* बोवाली or (young ones) *Lopchi* लोपची ; Rabha : *Na-jek.*

D. 5. P. 1/13–16. V. 8–10. A. 4/82–89. C. 17. Barbels 2 pairs.



TEXT-FIG. 81.—*Wallago attu* (Bloch).

Body elongated and compressed, the dorsal profile being nearly straight. A deep-cleft mouth. Length of head 5-5½, of caudal 9, height of body 5½-6½ in the total length.

Barbels : The maxillary are longest reaching beyond the front end of the anal.

Fins : A gap between anal and caudal which is forked, the upper lobe the longer.

Colour : Uniform grey.

Size : Very large specimens are brought into the district by rail; our longest local specimen was 2½ feet long. Day says it attains at least six feet.

Habitat: Deep, still pools in clear streams in the south of our area (*e.g.* Konai and Bania Rivers)—also tanks inside the forest (*e.g.* Borojhar). Day gives—'Fresh waters throughout India, Ceylon, and Burma, sometimes within tidal influence.'

Habits: According to Day it is 'a voracious and not very clean feeder, said mostly to feed at night time.' Thomas ('Rod in India') says they are found in *Mahseer* rivers as well as tanks and recommends fishing for them with live-bait or a spoon. We have never heard of their being taken on rod and line in rivers in our area but, in Bihar, they are taken on rod and line with a live frog in dead water. This is one of the fish known as a 'fresh-water sharks' and is not popular in tanks because it eats other fish.

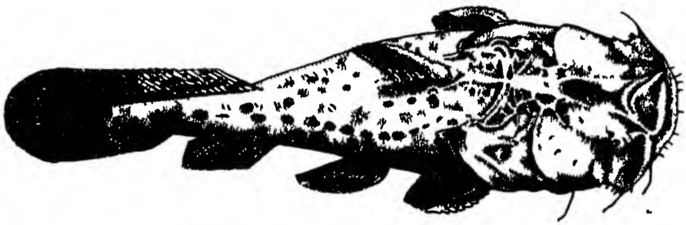
Chaca chaca (Ham.), *F.B I.*, No. 118 *Chaca lophioides.*

Plate 3, fig. 14.

Bengali : *Chega* চেগা ; Mechi : *Gageb* ; Rabha : *Chega-bakau.*

D. 1/3-4 : 19–25 P. 1/5. V. 6. A. 6–10 : 8–12. C. 11.

A flat (vertically compressed) fish with a very wide mouth. The whole upper surface is covered with tubercles and with many short soft spines which also occur along the edge of the lower lip. Its large chin is provided with an adhesive apparatus formed of radiating pleats. Length of head 3, of caudal 6–8, height of body 6 in the total length.



TEXT-FIG. 82.—*Chaca chaca* (Hamilton).

Fins : Dorsal and pectorals each with one strong spine enclosed in skin. Second anal and second dorsal confluent with caudal.

Colour : Dark brown, lighter on the chin ; pectorals and pelvics lighter with dark mottlings.

Size: We have taken them up to 6 inches in length; Day says they attain 8 inches.

Habitat: Rivers of the Duars and Terai. Day gives—'Brahmaputra, Ganges, and Irrawaddy Rivers, and tanks in connection with them; also some fresh waters of Bombay.'

Habits: Hamilton begins his description of this fish with the words—'Of all the horrid animals of this tribe the *Cheka* is the most disagreeable to behold' and ends with—'All persons turn away from it with loathing.' It is said to bury itself in mud and wound the feet of fishermen with its formidable dorsal spine.

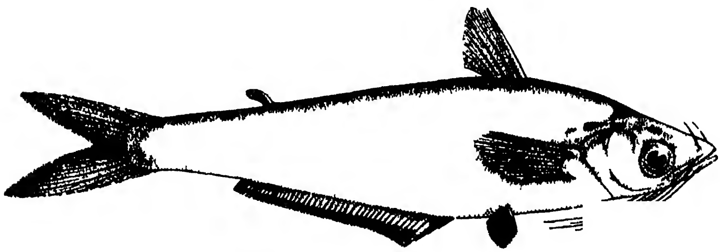
[**Eutropiichthys vacha** (Ham.)], *F.B.I.*, No. 135.

Bengali: *Bacha* or *Bhacha* বাচা or ভাচা; Hindi: *Bachwa* বচবা.

D. 1/7 | 0. P. 1/13–16. V. 6. A. 3-4/42–47. C. 17. Barbels 4 pairs.

Very like *Pseudeutropius murius* in appearance, the distinction being that in *P. murius* the dorsal is much in advance of the pelvics, whereas, in the present species the dorsal and pelvics are practically opposite one another.

Fins: An adipose dorsal always present.



TEXT-FIG. 83.—*Eutropiichthys vacha* (Hamilton).

Colour: Silvery, darker on the back.

Size: Our longest 6·7 inches. Day says 'upwards of a foot'

Habitat: We have never found it locally but it is frequently brought to Siliguri by rail, probably from Bihar. Day says—'From the Punjab through the large rivers of Sind, Bengal, and Orissa'.

Habits: It is said to take a fly in Bihar and is regarded as good eating.

[**Pangasius pangasius** (Ham.)], *F.B.I.*, No. 152 *Pangasius buchanani*.

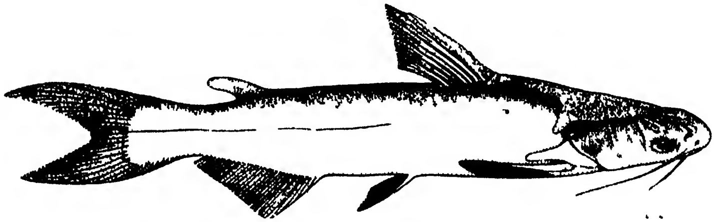
Bengali: *Pangas* পাঙ্গাস্.

D. 1/7 | 0. P. 1/12. V. 6. A. 31-34(4-5/27–29). C. 10. Barbels 2 pairs.

Head flat. Tail constricted behind the adipose fin but expanding again before the root of the caudal fin. Day gives—Length of head 5½-6, of caudal fin 5-5¼, height of body 4-5 in total length.

Barbels: 'The maxillary reach the base of the pectoral fin; the mandibular are half as long as the head.' (*Day*)

Fins: Caudal deeply forked, upper lobe slightly the longer.



TEXT-FIG 84.—*Pangasius pangasius* (Hamilton).

Colour: Our notes say brown but the specimen was not fresh. Day says—'Silvery, darkest along the back and glossed with purple on the sides; cheeks and under surface of the head shot with gold'

Size: Our only specimen was 2½ feet long; Day says they grow up to 4 feet.

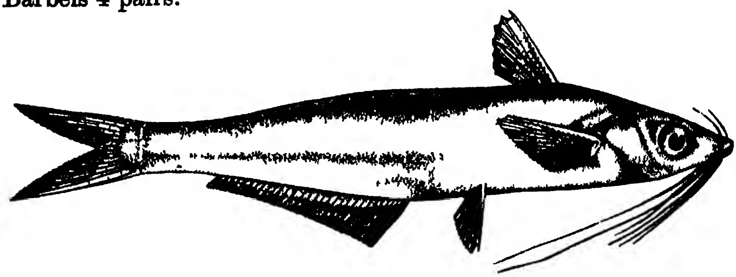
Habitat: Our specimen was from Siliguri bazaar. Day gives—'Large rivers and estuaries of India, Assam, Burma, and perhaps the Malay Archipelago.'

[**Pseudeutropius garua** (Ham.)], *F.B.I.*, No. 151.

Plate 3, fig. 11.

Bengali: *Garua* গারুয়া.

D. 1/7 | (0 in young). P. 1/12. V. 6. A. 3/26–33. C. 17. Barbels 4 pairs.



TEXT-FIG. 85.—*Pseudeutropius garua* (Hamilton).

Very like *P. murius* but not so silvery and the back is speckled instead of being uniform grey.

Barbels : Longer than in *P. murius*, the longest pair (maxillary) reach the ventral fin. In *P. murius* they are only as long as the head.

Fins : The adipose fin in this species is only present in young fishes and disappears later.

Size : Our longest was 9·6 inches. Day says it attains upwards of two feet.

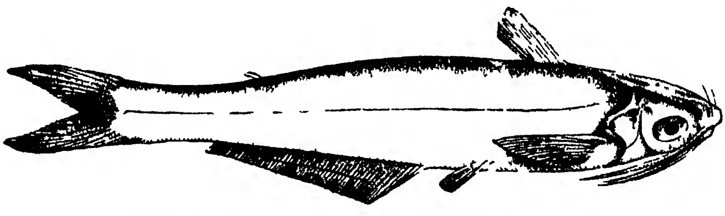
Habitat : The only specimens we have seen were those exposed for sale in Siliguri bazaar. Day gives—' Found generally throughout the larger rivers of Sind, India, Assam, and Burma.'

Pseudeutropius murius (Ham.), *F.B.I* , No. 148.

Bengali : *Muribacha* মুরিবাচা ; Nepalese : *Cherki* चेरकी .

D. 1/7 | 0. P. 1/11(1/10 Day). V 6. A. 3/35–40. C. 17. Barbels 4 pairs

Whole body laterally compressed ; dorsal and ventral outlines approximately equally curved. Very like *P. garua* the chief difference being that in *P. garua* the longest barbels (maxillary) reach to the pelvics, whereas in *P. murius* they are only as long as the head. Further differences are that in *P. garua*, the adipose dorsal is absorbed in adults and the anal rays are less than 37, whereas, in *P. murius*, the adipose dorsal is always present and anal rays are more than 37. Length of head $5\frac{1}{2}$–7, of caudal $5\frac{3}{4}$-6, height of body $5\frac{1}{2}$-6 in the total length.



TEXT-FIG. 86 —*Pseudeutropius murius* (Hamilton).

Colour : Silvery grey, darkest on the back.

Size : Our longest 11·8 inches. Day says 6 or 8 inches.

Habitat : Our only specimens have been taken in the Tista.[1] Day gives—' Rivers of Sind, Orissa, the Jumna and rivers of Bengal and Assam.'

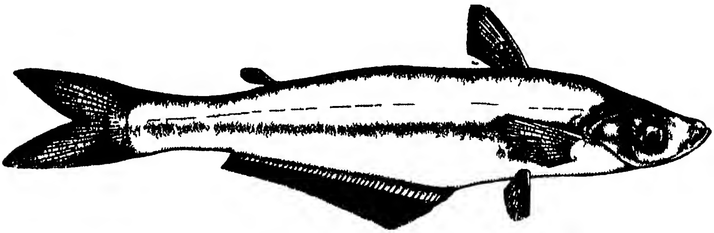
[1] A re-examination of the material showed that these specimens represented a new species of *Clupisoma*, which has been described as *C. montana* (*Journ. Bombay Nat. Hist.*, Vol. XXXIX, p. 673, 1937). —*S. L. Hora.*

[**Silonia silondia** (Ham.)], *F.B.I.*, No. 154 *Silundia gangetica.*

Bengali: *Shilong* শিলং.

D. 1/7 | 0. P. 1/11–13. V. 6. A. 4/36–44. C. 17. Barbels 1 pair.

Very like *Eutropiichthys vacha* or *Pseudeutropius spp.* but having only one pair of minute (maxillary) barbels. Other distinguishing features are a longer snout, caniniform teeth and red lips in this species.



TEXT-FIG 87.—*Silonia silondia* (Hamilton).

Colour: Silvery, darker on the back.

Size: Day says it attains 6 ft. or more. Our specimen was 9 inches long.

Habitat: Our only specimen was from Siliguri bazaar. Day gives—'Estuaries of India and Burma, ascending the larger rivers almost to their sources.'

KEY TO THE FAMILY BAGRIDÆ IN THIS LIST.

Dorsal spine weak .. .. .. *Olyra kempi* (p 94).
Dorsal spine strong :—
  Dorsal and Pectoral spines not hollow .—
    No shoulder-blotch :—
      Longest barbels reach Pelvics :—
        A black spot on hinder-edge of Adipose fin— *Mystus seenghala* (p. 93)
        Eight or 9 black spots along lateral-line *Mystus menoda* (p. 92)
      Longest barbels reach Caudal; a black spot, or diffused darkening, at the base of Dorsal spine .. *Mystus cavasius* (p. 91)
    A darker band along lateral-line broadening into a shoulder-blotch :—
      Barbels long :—
        Longest barbels reach Pelvics, upper lobe of Caudal barely longer than lower .. .. *Mystus vittatus* (p 93)
        Longest barbels reach Anal; upper Caudal lobe longer— *Mystus bleekeri* (p. 91)
      Barbels short (longest much shorter than the head)— *Leiocassis rama* (p. 90)
  Dorsal and Pectoral spines stout, bony and hollow *Rita rita* (p. 95)

Leiocassis rama (Ham.), *F.B.I.*, No. 173.

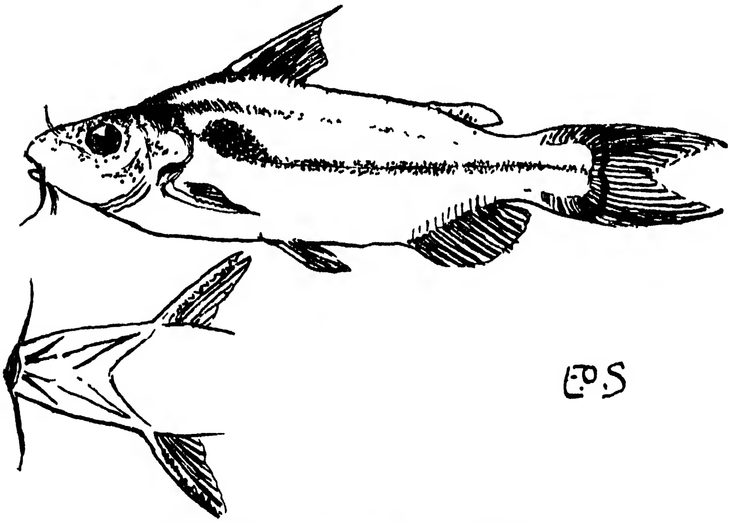
Plate 3, fig. 4.

D. 1/6 | 0. P. 1/5. V. 6. A. 13. C. 20(?). Barbels 4 pairs.

In general appearance resembles those species of *Mystus* which have a shoulder-blotch and longitudinal bands but has much shorter barbels. It therefore somewhat resembles *Batasio batasio* from which it is distinguished by having a shorter adipose fin and a longer anal.

Barbels : Nasal pair hardly reach the orbit ; the longest pair (mandibular) reach the centre of the eye.

Fins : Base of the adipose fin shorter than that of the anal. Dorsal spine moderately stout, unserrated ; pectoral spine stout with 10 recurved hooks on the inner side. Adipose fin shorter than the rayed dorsal.



TEXT-FIG. 88.—*Leiocassis rama* (Hamilton).

Colour : Leaden-grey above, whitish beneath. A well-marked but narrow dark band along the lateral line terminating in a shoulder-blotch. Another fainter band between the lateral line and the dorsal ridge extending from the opercle to the tail.

Size : Our longest specimen about 3 inches. Day says it does not exceed this size.

Habitat : All our specimens were from the Mahanadi near Siliguri. Day gives—' Eastern Bengal and Assam.'

Mystus bleekeri (Day), *F.B.I.*, No. 172 *Macrones bleekeri*.

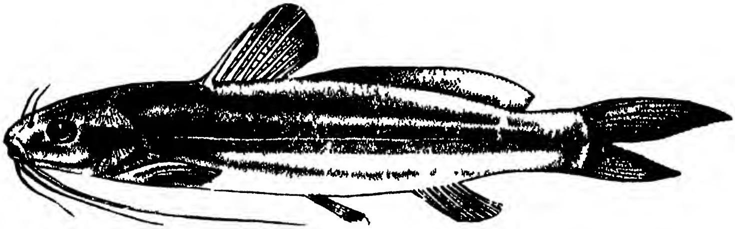
Plate 3, fig. 6.

D. 1/7 | 0. P. 1/9-10. V. 6. A. 3/6-7. C.17. Barbels 4 pairs.

General shape like others of the genus.

Barbels: The longest (maxillary) barbels reaching to the base of the anal fin.

Fins: Adipose fin commencing just behind the rayed dorsal and three times as long. The rayed dorsal not as high as the depth of the body. The upper lobe of the caudal fin distinctly the longer.



TEXT-FIG. 89.—*Mystus bleekeri* (Day).

Colour: Leaden above, yellow beneath. A dark band along the lateral line ending in a dark shoulder spot in all our specimens but, according to Day, the latter may be absent. Above and below this band are lighter bands.

Size: Our longest specimen 3½ inches. Day says—'not attaining a large size'.

Habitat: All streams in the Terai and Duars. Day gives—'Sind, Jumna, upper waters of the Ganges, and Burma.'

Mystus cavasius (Ham.), *F.B.I.*, No. 163 *Macrones cavasius*.

Plate 3, fig. 3.

Bengali: *Tengra* টেংরা.

D. 1/7 | 0. P. 1/8. V. 6. A. 4/7–9. C. 16. Barbels 4 pairs.

General shape like others of the genus.

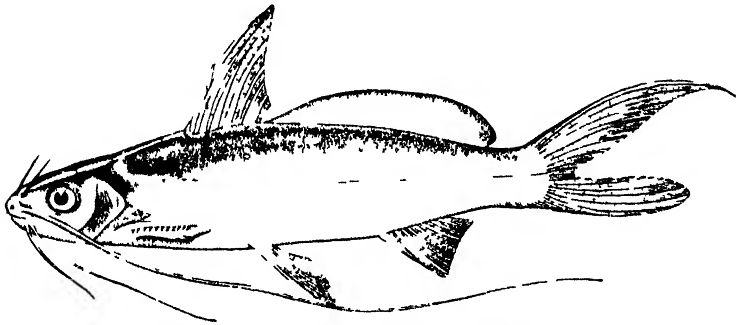
Barbels: The longest pair (maxillary) reach nearly to the base of the caudal fin.

Fins: The rayed dorsal fin is rather higher than the depth of the body and pointed. The adipose fin commences just behind the rayed dorsal and is three times as long. The upper lobe of the caudal is the longer.

Colour: Leaden above, yellowish beneath. There is usually a black spot covering the basal bone of the dorsal fin but in some of our specimens this amounts to no more than a darkening just in front of this fin. There may be a bluish band along the

lateral line but nothing that could be confused with the lateral stripes in *M. vittatus* and *M. bleekeri*.

Size: Our longest specimen was 6½ inches. Day says it attains 18 inches.



TEXT-FIG. 90.—*Mystus cavasius* (Hamilton).

Habitat: Some of our specimens were from the Magurmari, a muddy stream in the Apalchand forest in the west of the Duars; others were from Siliguri bazaar. Day gives—'From Sind, throughout India, Assam and Burma.'

[Mystus menoda (Ham.)].

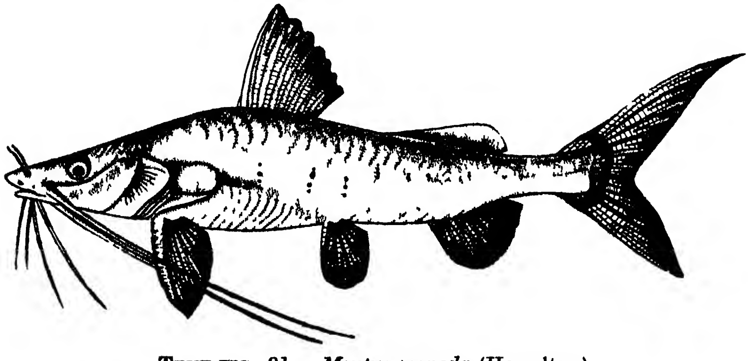
1822. *Pimelodus menoda*, Hamilton, *Fish. Ganges*, p. 203.

Plate 3, fig. 2.

See Chaudhuri's *Rec. Ind. Mus.*, VII, pp. 210-212 (1912).

Hindi (Bihar): *Belawna* बेलावना.

D. 1/7 | 0. P. 1/9. V. 6. A. 3–5/8. C. 17. Barbels 4 pairs.



TEXT-FIG. 91.—*Mystus menoda* (Hamilton).

Very like *M. seenghala* except in colour. There is no spot on the adipose fin but a series of 8 or 9 small black spots along the lateral line.

Size : Our longest specimen was 9·8 inches.

Habitat : We have only seen them exposed for sale in Siliguri bazaar.

Mystus seenghala (Sykes), *F.B.I.*, No. 157 *Macrones seenghala.*

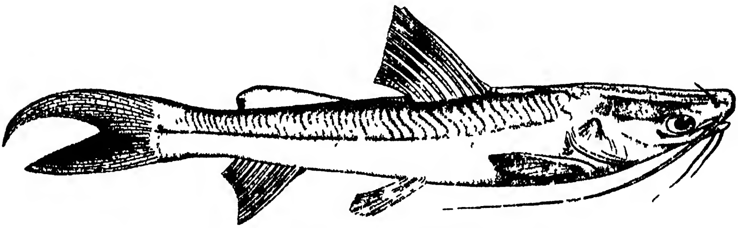
Plate 3, fig. 1.

Bengali : *Air* आइर ; Hindi : *Ari* अरी or *Pogal* पोगल.

D. 1/7 | 0. P. 1/9. V. 6. A. 3/8-9. C. 19–21. Barbels 4 pairs.

Snout chisel-shaped : tail constricted behind the adipose fin but expanding again to the base of the caudal which is deeply cleft, the lobes pointed, the upper one being the longer. The adipose fin is about the same length as the rayed dorsal. The occipital process and a patch in front of the rayed dorsal bony and rough.

Barbels : The longest pair (maxillary) reach to the end of the pelvics.



TEXT-FIG. 92.—*Mystus seenghala* (Sykes).

Colour : Darker above and lighter beneath but without any longitudinal bands. A black spot about the size of the eye near the base of the adipose fin close to its posterior edge.

Size : Our longest specimen was 20 inches.

Habitat : We have caught them in the Bania River, Eastern Duars and also seen them very frequently exposed for sale in Siliguri bazaar. Day gives—'The Indus, salt-ranges of the 'Punjab, Jumna, and Ganges certainly as low as Delhi, also the 'Deccan, Kistna River to its termination, and Assam.'

Mystus vittatus (Bloch), *F.B.I.*, No. 166 *Macrones vittatus.*

Bengali : *Tengra* টেংরা ; Mechi : *Na-tingna* ; Rabha : *Tengana.*

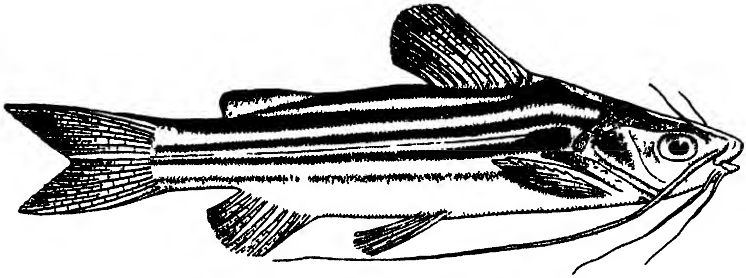
D. 1/7 | 0. P. 1/9. V. 6. A. 2-3/7–9. C. 17. Barbels 4 pairs.

General shape like others of the genus.

Barbels : The longest pair of barbels (maxillary) reach to the base of the ventral fins.

Fins : The adipose fin is variable but always shorter than in *M. cavasius* being about the same length as the rayed

dorsal or a little longer. The upper lobe of the caudal fin is barely longer than the lower.



TEXT-FIG. 93.—*Mystus vittatus* (Bloch).

Colour: Leaden above, yellow beneath. A dark band along the lateral line ending in a very dark shoulder spot. Above and below this band are lighter bands.

Size: Our longest specimen 4 inches. Day says it attains 7 or 8 inches.

Habitat: Streams in the Terai and Duars. Day gives—'Throughout Sind, the continent of India, Assam, Burma, Siam also Ceylon.'

Olyra kempi Chaudhuri.

1912. *Olyra kempi*, Chaudhuri, *Rec. Ind. Mus.*, VII, p. 443, fig. 4.

Plate 3, fig. 8.

Bengali: *Bot-singhi* বোট-শিঙ্গি; Mechi: *Tara-ranji*; Rabha: *Na-hongsher*.

D. 7 | 0. P. 1/4. V. 5. A. 17-19. C. 12. Barbels 4 pairs.

Body slender, cylindrical in front, laterally compressed behind. The caudal is forked with an elongated upper lobe; the adipose fin is long and low. The distinction between this species and *O. longicaudata* (McClell.) from the descriptions at our disposal seems to lie in the number of rays in the anal fin (17–19 instead of 23).

TEXT-FIG. 94.—*Olyra kempi* Chaudhuri. (Copied from *Rec. Ind. Mus.*)

Barbels: Maxillary pair the longest, reaching at least to base of the pectoral and sometimes beyond the end of it.

Colour: Dark brown above, grey beneath.

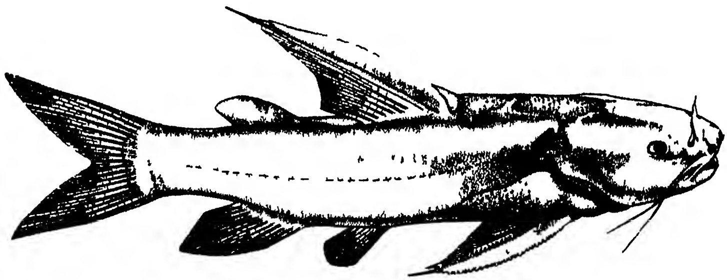
Size : Our longest 4·7 inches and said not to exceed this.
Habitat : Rivers of the Terai and Duars.

[Rita rita (Ham.)], *F.B.I.*, No. 175 *Rita buchanani.*

Bengali : *Rita* রিটা ; Hindi (Bihar) : *Chona* चोना.

D. 1/6 | 0. P. 1/10. V. 8. A. 4/10(4-5/9. Day). C. 19. Barbels 3 pairs.

A stockily-built fish with very stout, hollow, bony spines to the dorsal and pectoral fins. That of the dorsal is very slightly serrate on the hinder edge, those of the pectorals strongly denticulate along both edges. The surface of the back between the head and the dorsal, as well as a shield above the pectoral, is bony and granulated.



TEXT-FIG. 95.—*Rita rita* (Hamilton).

Colour : Greenish-brown.
Size : We have seen specimens up to 18 inches long ; Day gives—' attaining at least 4 feet in length '.
Habitat : We have only seen them exposed for sale in Siliguri bazaar. Day gives—' Indus and affluent rivers, Jumna and Ganges, also the Irrawaddy.'
Habits : Day remarks that it is a very foul feeder.

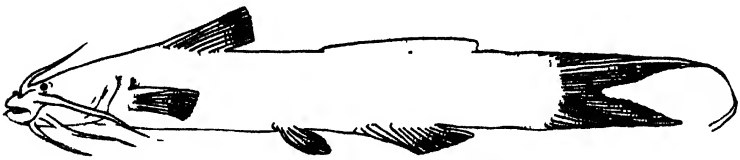
Amblyceps mangois (Ham.), *F.B.I.*, No. 131.

Hindi : *Billi* (Day) बिल्ली.

D. 1/6 | 0. P. 1/7. V. 6. A. 2-3/7-9. C. 19. Barbels 4 pairs.

Head flat and very wide with a large mouth and very small eyes. The body tapers uniformly from head to tail in the horizontal plane but is almost parallel-sided in the vertical plane. General appearance somewhat like that of *Olyra* but easily distinguished by the number of anal rays.

Fins: We have two forms one with the caudal fin deeply and the other with it slightly forked. The rays of the dorsal and anal fins partly enveloped in skin.



TEXT-FIG. 96 —*Amblyceps mangois* (Hamilton). Sketch of a Siamese specimen. (Copied from *Rec. Ind. Mus.*)

Colour: Brownish-grey, lighter beneath.

Size: Our longest specimen 4 inches. Day gives up to 5 inches.

Habitat: Rivers of the Terai and Duars. Day gives—'The Himalayas; found in the Jumna for some considerable distance from the hills, also through Burma to Moulmein.'

Habits: Day notes that it bites viciously and lives for sometime out of water.

KEY TO THE FAMILY SISORIDÆ IN THIS LIST.

Paired fins more or less horizontal and belly flattened, adapted for lying along the bottom :—
- Dorsal spine not hard or bony :—
  - Upper margin of Caudal produced into a long filament— *Sisor rhabdophorus* (p. 107)
  - No Caudal filament :—
    - An adhesive apparatus under the thorax consisting of a dozen or more *transverse* parallel folds—*Pseudecheneis sulcatus* (p. 106)
    - No obvious adhesive apparatus .. *Euchiloglanis hodgarti*. (p. 100)
- Dorsal spine hard and bony :—
  - An adhesive apparatus of *longitudinal* folds well developed :—
    - Longest barbels reach the gill-opening :—
      - No teeth on the palate *Glyptothorax telchitta* (p. 103)
      - Teeth on the palate *Glyptothorax lineatus* (p. 102)
    - Longest barbels reach Pectorals *Glyptothorax horai* (p. 101)
  - Adhesive apparatus absent or weak :—
    - Caudal and Pectorals produced into filaments— *Bagarius bagarius* (p. 97)
    - No filaments from fins :—
      - Gill-openings narrow :—
        - Caudal very deeply forked *Erethistes elongatus* (p. 98)
        - Caudal shallowly forked .. *Erethistes hara* (p. 99)
      - Gill-opening wide :—
        - Origin of Pelvics nearer to base of Caudal than to tip of snout .. .. .. *Laguvia shawi* (p. 104)
        - Origin of Pelvics equidistant between base of Caudal and tip of snout .. .. *Laguvia ribeiroi* (p. 104)

Not specially adapted for lying along the bottom :—
Gill-membranes attached to isthmus; 4 mandibular barbels in a transverse row on chin .. .. *Batasio batasio* (p. 97)
Gill-membranes free from isthmus; 2 inner mandibular barbels in front of outer pair .. .. *Nangra punctata* (p. 106)

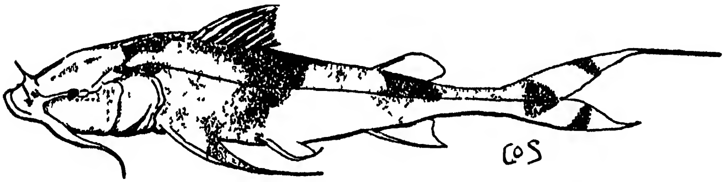
Bagarius bagarius (Ham.), *F.B.I.*, No. 207 *Bagarius yarrellii.*

The Goonch.

Bengali: *Bagha-ar* বাঘা-আড়; Hindi: *Gaunch* गौंच (Bihar): *Baghar* বাঘার.

D. 1/6 | 0. P. 1/12. V. 6. A. 3/10–12. C. 17. Barbels 4 pairs.

An ugly looking fish with a broad, flat head and a body tapering gradually towards the tail. Nasal barbels small and erect, maxillary pair large and fleshy, rather longer than the head. *Fins*—there are whip-like prolongations to the upper lobe of the caudal and pectorals. There is a bony and granular surface just in front of the dorsal fin.



TEXT-FIG. 97.—*Bagarius bagarius* (Hamilton).

Colour: Yellowish-brown with darker zones, one from the rayed dorsal to behind the pectorals and another from the adipose dorsal to the anal.

Size: We have seen one 7 ft. 1 in. long exposed for sale in Siliguri bazaar, also one weighing 45 lb. caught on rod and line in the Sankos River. Day says it attains 6 ft. or more and records one caught on rod and line measuring 5 ft. and weighing 136 lbs.

Habitat: Usually only in large rivers but we have had it from the Riyang. Day gives—'Large rivers of India and Java, descending to their estuaries.'

Habits: Thomas ('Rod in India') says this is probably the largest fish caught on rod and line in India. As it takes *Mahseer* bait and then lies up on the bottom without fighting it is not popular with anglers.

Batasio batasio (Ham.), *F.B.I.*, No. 224 *Gagata batasio.*

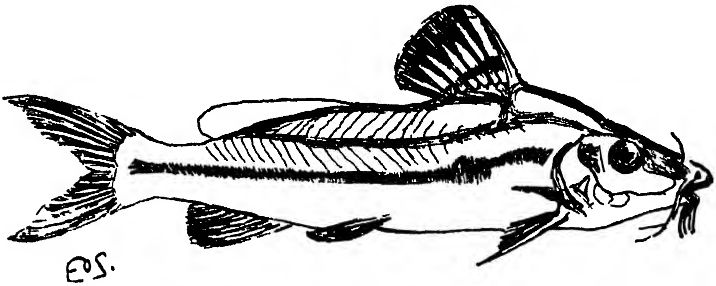
D. 1/7 | 0. P. 1/9. V. 6. A. 2/7. C. 17. Barbels 4 pairs.

In general appearance resembles those species of *Mystus* which have a shoulder blotch and longitudinal bands, but has

shorter barbels. It therefore somewhat resembles *Leiocassis rama* from which it is distinguished by having a longer adipose fin and a shorter anal.

Barbels: The longest pair do not exceed the length of the head.

Fins: Base of the adipose fin longer than that of the anal.



TEXT-FIG. 98.—*Batasio batasio* (Hamilton).

Colour: Leaden above, yellow beneath. A dark longitudinal band along the lateral line expanding into a shoulder-blotch immediately below the dorsal fin. A second fainter and somewhat curved dark band midway between the lateral line and the dorsal ridge, commencing at the top of the opercle and ending about the middle of the adipose fin. It is connected with the dark colour of the dorsal ridge at the front part of the rayed dorsal.

Size: Our longest specimen about 4 inches. Day says—'attaining three inches'.

Habitat: Clear streams of the Terai and Duars. Day gives—'River Teesta.'

Erethistes elongatus Day, *F.B.I.*, No. 221.

Bengali: *Bot-tengra* বোট্-টেংরা; Rabha: *Na-taram*; Hindi (Bihar): *Powan* पोवान.

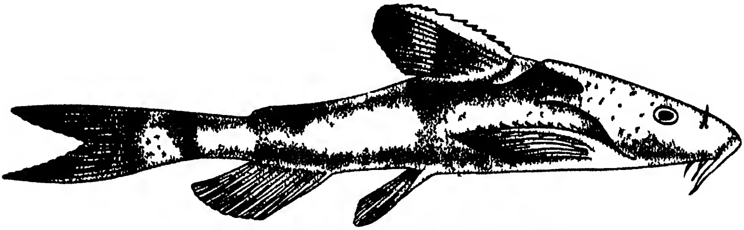
D. 1/6 | 0. P. 1/6. V. 6. A. 3/7-8. C. 17. Barbels 4 pairs.

A hard, bony little fish giving rather the impression of a miniature shark.

Fins: The dorsal spine is serrated on both edges; the pectorals stand out stiffly in a horizontal plane. The caudal is deeply forked, the upper lobe being considerably longer than the lower (in a specimen 3·3 inches long the upper was an inch long and the lower half an inch. Day's figure, reproduced below, does not show this).

Colour: Day describes the body as being banded. Our specimens are almost black except for the fins. The dorsal is

margined with a lighter colour the spine with alternate dark and light bands. Both the inner and outer margins of both lobes of the caudal are similarly checkered with darker and lighter colour. The pectoral, pelvic and anal fins are banded darker and lighter across their whole width. The adipose dorsal is black.



TEXT-FIG 99 —*Erethistes elongatus* Day.

Size: Our longest specimen was 3·3 inches.

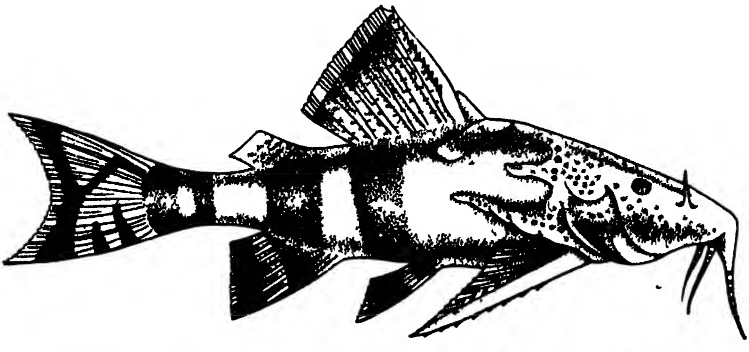
Habitat: Our specimens were from small streams near Siliguri and from the Phuljhora (in the Apalchand Forest, Western Duars). Day describes a single specimen from the Naga Hills.

Erethistes hara (Ham), *F.B.I.*, No. 218.

Plate 3, fig. 13.

Bengali: *Kutakanti* কুটকাঁটি or *Kurkati* কুর্কটি ; Mechi: *Rakheb*; Rabha: *Na-palthong.*

D. 1/6 | 0. P. 1/6. V. 6. A. 3/7-8. C. 15. Barbels 4 pairs.

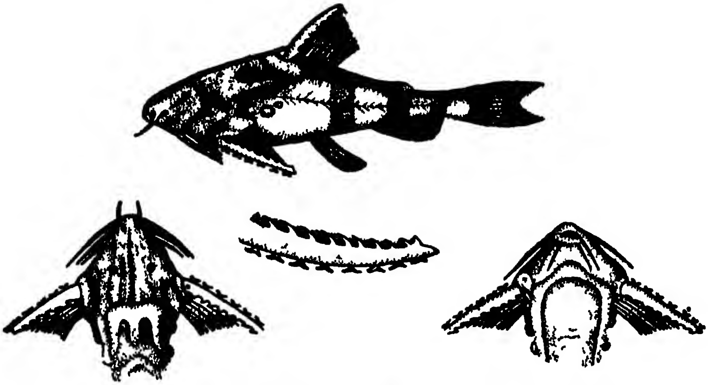


TEXT-FIG. 100.—*Erethistes hara* (Hamilton). An adult specimen.

Head flattened in the horizontal plane and body in the vertical plane. Viewed from above the horizontal pectorals give it an almost aeroplane-like appearance. The skin is very rough

with elevated spots or blunt bony spines. The caudal, though slightly forked, has not the elongated lobes of *E. elongatus*.

Colour: Olive brown with darker bands over the back opposite the pectoral, pelvic and anal fins, and another across the caudal. The pectoral spines are ringed with alternate darker and lighter bands, as are the larger barbels. Pectorals yellow with black dots.



TEXT-FIG. 101.—*Erethistes hara* (Hamilton). A young specimen.

Size: Our longest 6 inches. Day gives 5½ inches.

Habitat: Small streams of the Terai and Duars. Day gives—'Rivers and contiguous pieces of water, from Orissa, through Bengal, Assam, and Burma.'

Euchiloglanis hodgarti (Hora).

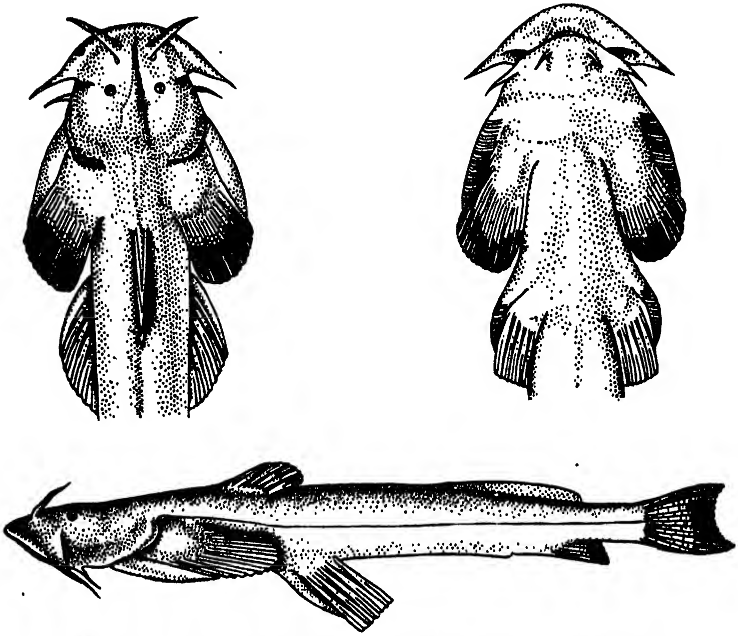
1923. *Glyptosternum hodgarti*, Hora, *Rec. Ind. Mus.*, XXV, p. 38, pl. ii, figs. 1, 2, 3.

Nepalese: *Til-kabri* तिल-कबरी.

D. 1/6 | 0. P. 1/17. V. 6. A. 2/6. C. 13. Barbels 4 pairs.

Body tapering from the wide, flat head towards the tail, the belly flattened between the horizontal pectoral fins and the partly horizontal ventrals. This part provides the fish with an adhesive apparatus which, however, is not so conspicuous as in *Pseudecheneis sulcatus* and the folds are only visible in fresh specimens. Day states that there is 'no thoracic adhesive apparatus' in this genus though he says that the chest 'appears to form a flat adhesive surface, bounded by the striated rays of the pectoral and pelvic fins'. Maxillary barbels wide and spreading, flattened at the base. Labial folds broadly interrupted, not reflected round the mouth.

Colour : Yellowish-brown.
Size : Our longest 3·4 inches.



TEXT-FIG. 102.—*Euchiloglanis hodgarti* (Hora). (Copied from *Rec. Ind. Mus.*)

Habitat : Riyang and Rangbi Rivers from 2,000 to 5,000 ft. elevation. (Rapid mountain streams with stony beds.)

Glyptothorax horai Shaw and Shebbeare.

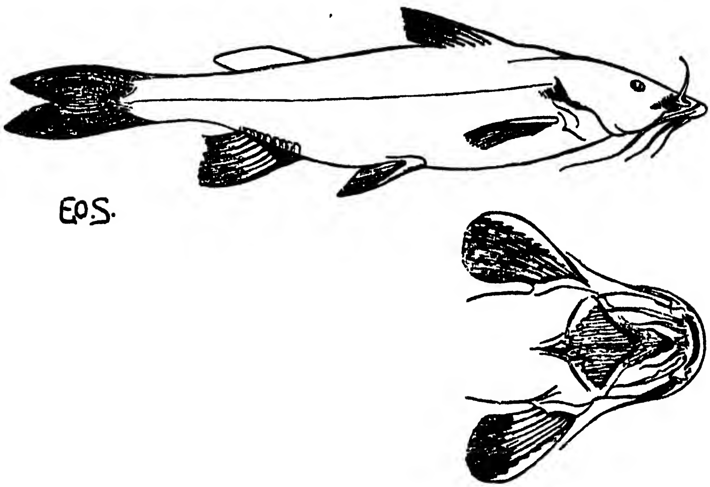
1937. *Glyptothorax horai*, Shaw and Shebbeare, *Jour. Bom. Nat. Hist. Soc.*, XXXIX, p. 188.

Nepalese : *Kala Kabri* काला-कबरी.

D. 1/6 | 0. P. 1/9. V. 6. A. 1/9. C. 19. Barbels 4 pairs.

Length of head $4\frac{1}{3}$, height of body $5\frac{1}{4}$ in total length. Width of head ·7 of its length. Width of mouth $\frac{1}{3}$ that of head. Upper jaw the longer; a very slight fringe on upper lip. *Barbels* : the maxillary pair extend half way along the pectoral fin ; the nasal pair reach the back of the orbit ; the outer (longer) pair of mandibular barbels reach the base of the pectorals. Teeth on the jaw but not on the palate. *Fins* : dorsal $\frac{3}{4}$ height of body ; spine moderately strong, smooth ; adipose dorsal longer than rayed dorsal and 5/8th of interspace between them. Pectorals

reach to half way between base of pectorals and pelvics; spine strong, flattened, with 8 or 9 strong curved teeth internally —not plaited. Pelvics with fine transverse marking. Caudal peduncle about half as high as long. Adhesive apparatus extends from lip to half way along base of pectoral. On the gill-covers it curves outwards but on lip and thorax it consists of longitudinal folds; laterally it does not extend quite to the pectorals. In no other *Glyptothorax* that we know does the adhesive apparatus extend to the lip.



TEXT-FIG. 103.—*Glyptothorax horai* Shaw and Shebbeare.

Colour: Brownish yellow with a dark blotch on the shoulder. Anal and caudal fins darker at base and tip.

Size: Our longest specimen measured 4·4 inches.

Habitat: Streams of the Terai (Bengal).

The type specimen is in the Indian Museum, Calcutta.

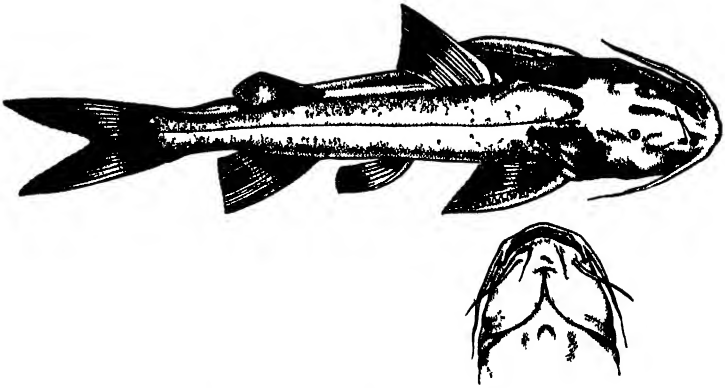
Glyptothorax lineatus (Day), *F.B.I.*, No. 217 *Euglyptosternum lineatum.*

D. 1/6 | 0. P. 1/10. V. 6. A. 3/9-10. C. 17. Barbels 4 pairs.

The adhesive apparatus on the chest has a smooth space in the middle, though this may be narrow in small specimens.

Colour: Mottled dark brown. Day says there is a narrow light band along the side but in our specimens this is very indistinct. The fins are paler with darker bases and a darker band across each.

Size : Our largest 7½ inches long. Day gives up to 12½ inches.



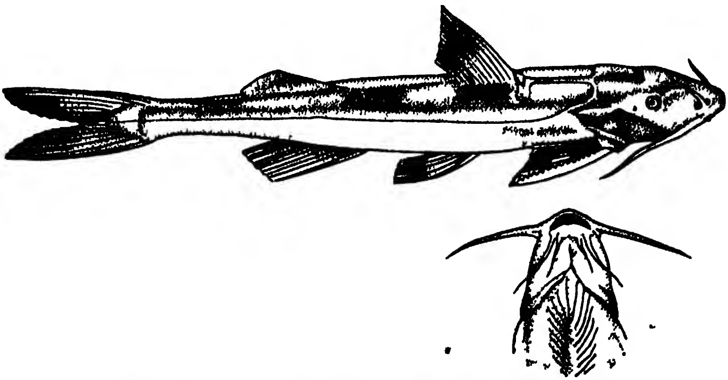
TEXT-FIG. 104.—*Glyptothorax lineatus* (Day).

Habitat : Small rivers of the Terai (Sivoke River) and Duars (Ghish and Chel Rivers).

Glyptothorax telchitta (Ham.), *F.B.I.*, No. 212 *Glyptosternum telchitta.*

D. 1/6 | 0. P. 1/8. V. 6. A. 2/9. C. 17. Barbels 4 pairs.

The skin is covered with small longitudinal elevations. The longest pair of barbels (outer mandibular) reach the gill-



TEXT-FIG. 105.—*Glyptothorax telchitta* (Hamilton).

opening. Day says the pupil of the eye is circular but we have found it slightly oval longitudinally. There is a pectoral adhesive apparatus.

Colour : Blackish brown, some yellow on the fins.

Size : Our longest 4 inches ; Day says 5 or 6 inches.

Habitat: We have caught them in the pools and runnels to which medium sized rivers of the Duars such as the Gish are reduced in the dry weather. Day gives—'Punjab, N.W. Provinces, Bengal, and Bihar.'

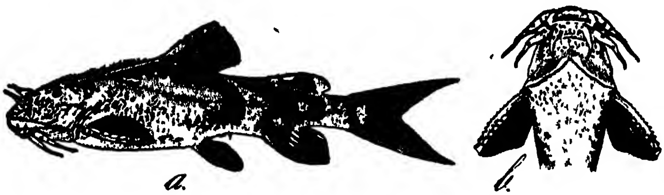
Laguvia ribeiroi Hora.

1921. *Laguvia ribeiroi*, Hora, *Rec. Ind. Mus.*, XXII, p. 741, pl. xxix, fig. 3.

D. 2/5–6 | 0. A. 1/8. Barbels 4 pairs.

Hora differentiates this species from *L. shawi* on the following points :—

L. shawi.	*L. ribeiroi.*
1. The nostrils are equidistant from the tip of the snout and the anterior margin of the eye.	The nostrils are nearer to the tip of the snout than to the anterior margin of the eye.
2. The origin of the ventral fin is distinctly nearer to the base of the caudal than to the tip of the snout.	The origin of the ventral fin is almost equidistant from the tip of the snout and the base of the caudal fin.
3. The dorsal spine is almost smooth along both the borders.	The dorsal spine is finely serrated along the whole of its anterior border and also along the upper third of the posterior border.
4. The skin covering the belly is smooth.	The skin covering the belly is corrugated to form a kind of rudimentary adhesive apparatus.



TEXT-FIG. 106.—*Laguvia ribeiroi* Hora. (Copied from *Rec. Ind. Mus.*)

(*a*) Lateral view, x 2; (*b*) Ventral surface of head and anterior part of body, x 2.

We have not had an opportunity to examine this species.

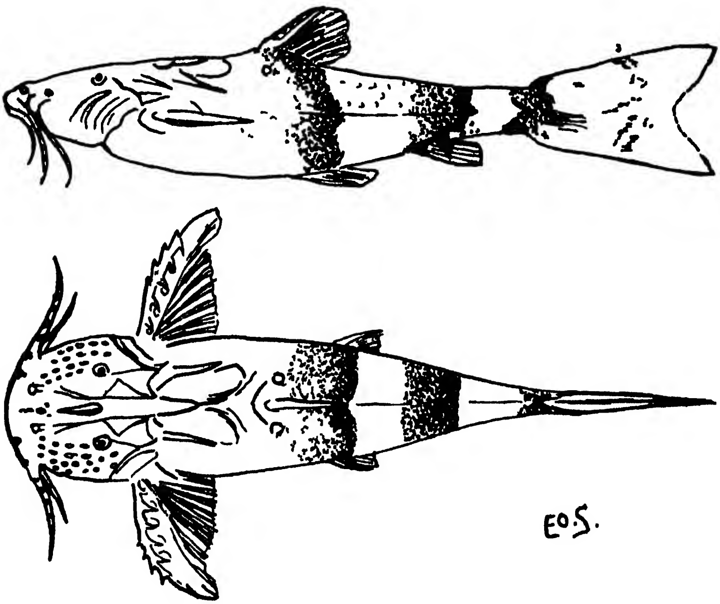
Habitat: The type specimen was found in the Khoila (Kharla ?) River, a tributary of the Tista at Jalpaiguri. It was 1¼ inches in length.

Laguvia shawi Hora.

1921. *Laguvia shawi*, Hora, *Rec. Ind. Mus.*, XXII, p. 740, pl. xxix, fig. 2.

D. 2/5-6 | 0. A. 1/8. Barbels 4 pairs.

Hora writes '* * * Closely resembles *Erethistes* 'from which it can be readily distinguished by the nature of its 'gill-openings which are very wide. From the Genus *Glypto-* '*thorax* it differs in the possession of scapular processes, the 'presence of free bony tubercles on the sides of the body and 'in the absence of a well-marked adhesive apparatus on the 'chest.' (*Note*: We have found a rudimentary adhesive apparatus on the thorax in fresh specimens.)



TEXT-FIG. 107.—*Laguvia shawi* Hora.

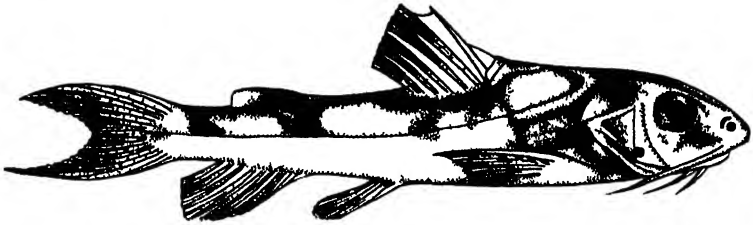
Hora describes this species as follows: '* * * Maxillary 'barbels broad at the base and reach the base of the pectoral 'fin. Dorsal spine strong, bony. Pectoral spine strong, almost 'as long as head, serrate externally, possesses about 7 hooked 'spines internally. Caudal fin has an almost semi-circular border 'with two sharp and pointed extremities. Two broad black 'bands on pale yellow body.'

Habitat: Sivoke River and various streams near Siliguri.

Nangra punctata Day, *F.B.I.*, No. 227.

D. 1/6 | 0. P. 1/8. V. 6. A. 3-4/8. C. 18. Barbels 3 or 4 pairs.

Day writes—'Very like the young of *Gagata cenia* but 'may be at once recognized by the position of the barbels and 'the broader head.' In *Gagata*, also, the gill-covers are confluent with the skin of the isthmus. According to Day's figures of the two species there is considerable difference in the form of the adipose fin.



TEXT-FIG. 108.—*Nangra punctata* Day.

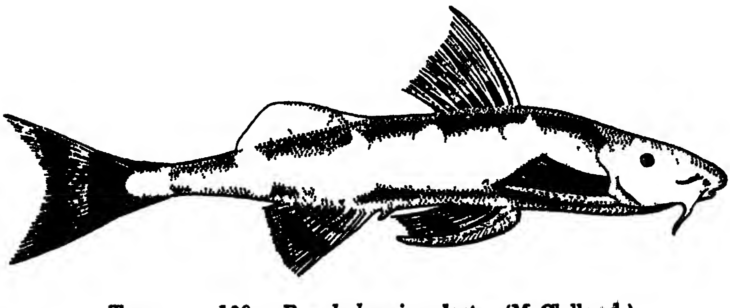
Colour: Day gives—'Coppery glossed with gold on the sides.' Our specimens have six transverse dark bands across the back reaching to just below the lateral line. The first of these is on the head, the second between the head and the pectoral, the third at the pectoral, the fourth at the anterior and the fifth at the posterior end of the adipose fin and the sixth across the tail.

Pseudecheneis sulcatus (McClell.), *F.B.I.*, No. 113.

Plate 3, fig. 12.

Nepalese: *Kabri* कबरी.

D. 1/6 | 0. P. 1/13. V. 6. A. 2–4/7–9. C. 17. Barbels 4 pairs.

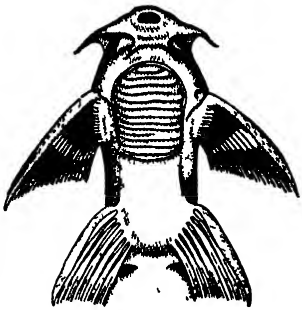


TEXT-FIG. 109.—*Pseudecheneis sulcatus* (McClelland.).

From the front of the dorsal fin the body tapers conically to the tail and forwards to the somewhat flattened head. The

under side of the thorax is flattened into an adhesive apparatus consisting of 14 transverse folds of skin between the pectoral fins, which are horizontal.

Colour: Greyish-brown with yellow blotches; fins red to yellow with black bands.



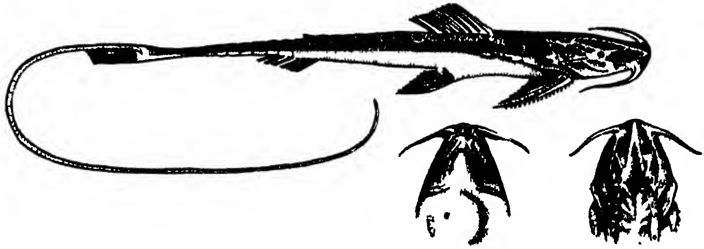
TEXT-FIG. 110.—Ventral surface of head and anterior part of body of *Pseudecheneis sulcatus* (McClelland).

Size: Our largest 5·8 inches. Day says they attain 7-8 inches.

Habitat: The Riyang River from 800 to 1,600 feet elevation; at this part it is a swift mountain stream with a stony bed. Day gives—'Darjeeling and Khasi Hills.'

Sisor rhabdophorus Ham., *F.B.I.*, No. 112.

D. 1/6. P. 1/8. V. 7. A. 6(2/4). C. 11. Barbels 3 pairs and several shorter ones.



TEXT-FIG. 111.—*Sisor rhabdophorus* Hamilton.

Elongated and tapering away from a flat head, the most striking feature being a filament from the upper edge of the caudal fin which may equal in length the rest of the fish. It

is protected by bony plates, those on the hinder half of the body being in the form of twelve osseous rings like those of a pipe-fish.

Colour : Blackish above, lighter below.

Size : Day says that the largest he had seen was 8 inches excluding the caudal filament.

Habitat : A single specimen was found by Dr. Hora among our fishes though we had not noticed it ourselves. Later Mukerji obtained a specimen from near Siliguri and, we think, he has since had more specimens from the Tista. Day gives—'Indus, Sind, Ganges, and Jumna rivers in Northern India, Bengal, and Bihar.'

Group VIII.—THE GAR-FISH.

Xenentodon cancila (Ham.), *F.B.I.*, No. 536 ***Belone cancila.***

The Gar-fish.

Plate 4, fig. 15.

Bengali : *Kankle* কাকলে or *Kakhya* কাখ্যা (in the Terai) : *Thona* থোনা ; Hindi : *Kawa* कावा ; Mechi : *Kankila* ; Rabha : *Nakunta.*

D. 15–18. P. 11. V. 6. A. 16–18. C. 15.

Body elongate, both jaws lengthened into a long beak. The dorsal and anal fins similar and, being arranged symmetrically close to the tail, give the fish a torpedo-like appearance.

TEXT-FIG. 112—*Xenentodon cancila* (Hamilton).

Colour : Day gives—'Greenish-grey above, becoming whitish along the abdomen ; a silvery streak having a dark margin extends along the body from opposite the orbit to the centre of base of caudal fin. The whole upper two-thirds of the body closely marked with fine black spots ; along the side, between the pectoral and anal fins, there are 4 or 5 larger blotches, these are absent in the young. Eyes golden.'

Size : Day says it attains at least 12 inches in length and we

Habitat : Streams of the Terai and Duars especially in pools in clear, gravelly perennial streams. Day gives—'Fresh waters of Sind, India, and Ceylon, also throughout Burma.'

Group IX.—THE PIPE-FISH.

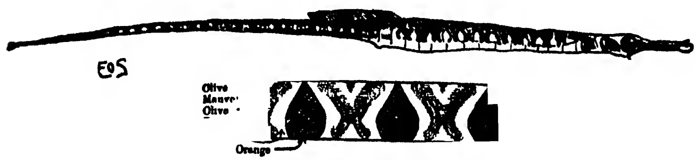
Doryichthys deocata (Ham.), *F.B.I.*, No. 1363.

Pipe-fish.

Plate 4, figs. 10 and 11.

D. 30. P. 15.

Body long, slender and sub-cylindrical covered with ridged bony rings, 16 on the body and 31 on the tail. Snout produced with small, terminal mouth. Dorsal fin opposite the vent covering 8 rings, 2 before and 6 after the vent. Pectoral, anal and caudal fins present but no pelvics. The caudal is very short. The male is smaller than the female and has a long groove on the abdomen in which he carries the eggs until they are hatched.



TEXT-FIG. 113.—*Doryichthys deocata* (Hamilton).
The lower figure represents the colour pattern of the fish.

Colour: The male is brown and inconspicuous. The female is orange in ground-colour, each segment ornamented with a fleur-de-lis-like pattern in brown and olive outlined in mauve.

Size: The male attains about 4½ and the female 5½ inches.

Habitat: The Panchenai River in the Terai and small rivers in Borojhar Forest (Central Duars). Day gives—'Rivers of Bengal and Bihar.'

Habits: They swim in an upright position. As noted above the male carries the eggs.

Group X.—THE FISH WITH PERCH-LIKE DORSALS.

KEY TO FISHES WITH PERCH-LIKE DORSALS IN THIS LIST.

Lateral line, if present, continuous; soft Dorsal the longer:—

- **A gap between spiny and soft Dorsals; eyes on the top of the head** .. .. ***Glossogobius giuris*** **(p. 114)**
- **Spiny and soft Dorsals touching:—**
  - **Body laterally compressed, more or less translucent, scales deciduous and uncountable** .. .. ***Ambassis*** **(p. 110)**
  - **Lateral line 50 or more:—**
    - **Caudal rounded; l.l. 50–55** ***Sciæna coitor*** **(p. 115)**
    - **Caudal tapering to a point; l.l. 50** ***Sciænoides pama*** **(p. 116)**
  - **Lateral line 28–31; snout pointed** ***Ctenops nobilis*** **(p. 113)**

Lateral line present and interrupted ; spiny Dorsal the longer :—
- Pelvics each a single filiform ray .. *Trichogaster* (p. 117)
- Pelvics normal :—
  - Lateral lines 46–57 .. .. *Nandus nandus* (p. 115)
  - Lateral line 32 or less :—
    - 3 anal spines ; l. l. 26–33 .. .. *Badis badis* (p. 112)
    - 9-10 anal spines ; l. l. 28–31 *Anabas testudineus* (p. 112)

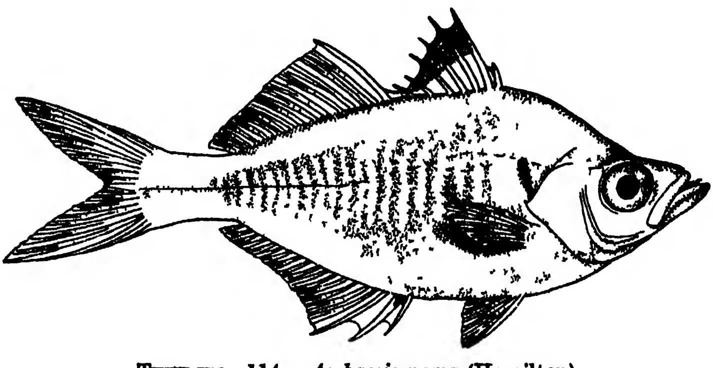
This group, as already pointed out, is a very wide and a somewhat loosely-connected one containing, as it does, our few local representatives of the whole order *Percomorphi* except the single genus *Ophicephalus* which we have made into another group—the Murrels. The fact that, of all Indian species in Day's Fishes (Fauna of British India Series) more than half (750 out of 1418) belong to this order, shows its importance in India as a whole. We have listed only 17, namely the 11 'Fishes with Perch-like Dorsals' given above and 6 'Murrels' (out of a total of 9 in Day).

The key above is an entirely artificial one and does not bring the species into their correct sequence (which is the one followed in our list on pages 4–8). Thus *Badis badis* and *Anabas testudineus*, which happen to come together in the key, are not close relations, in spite of their similarity in shape.

Ambassis nama (Ham.), *F.B.I.*, No. 628.

Bengali (local) : *Chanda* চাঁদা, (Lower Bengal) : *Nama chānda* নামা চাঁদা ; Hindi (Bihar) : *Channa* चन्ना.

D. 7 | 1/13–17. P. 13. A. 3/14–17. C. 17.



TEXT-FIG. 114.—*Ambassis nama* (Hamilton).

Deep and strongly compressed laterally, almost flat. Dorsal and ventral profiles about equally convex. We confused this fish with *A. ranga* until Dr. Hora pointed out that both species occurred among our specimens. The chief difference is that

A. nama has 2 or 3 large crooked canine teeth on either side of the lower jaw whereas in *A. ranga* all the teeth are small. The former is usually not quite so deep in the body as the latter, the height of the body in the total length being 2¾-3 in *A. nama* against 2⅓-2½ in *A. ranga*.

Colour: Translucent yellowish with a silvery wash on the sides, covered all over with minute black dots which coalesce to form a shoulder spot just behind the gill-opening.

Size: Day says it attains 3 or 4 inches; our largest was 2½ inches long.

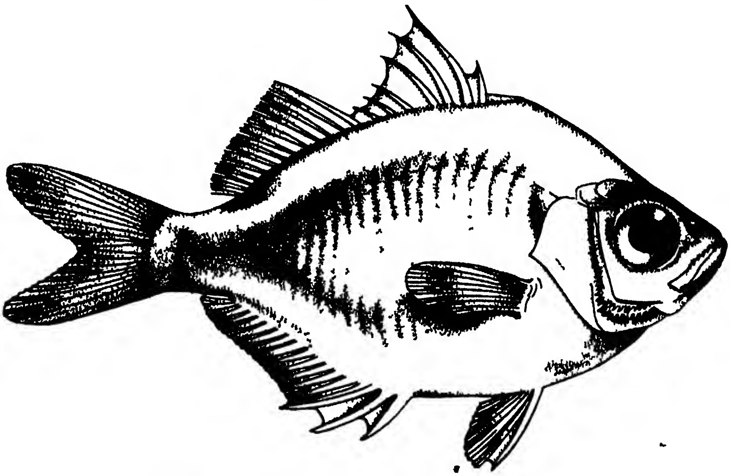
Habitat: Our specimens of this species were from the Indong Jhora (Central Duars) and from streams about Siliguri. It is probably common throughout the Terai and Duars. Day gives—'Throughout the fresh waters of India, Assam, and Burma.'

Ambassis ranga (Ham.), *F.B.I.*, No. 629.

Bengali (local): *Chanda* চান্দা (Lower Bengal): *Ranga chānda* রাঙ্গা চান্দা; Hindi (Bihar): *Channa* চান্না.

D. 7 | 1/13–15. P. 11. A. 3/14–16. C. 17. L. r. 60–70.

In shape and colour this fish resembles *A. nama* but is rather deeper in the body. The chief distinction is in the teeth which are all small in *A. ranga*.



TEXT-FIG. 115.—*Ambassis ranga* (Hamilton).

Size: We have had them up to about 2½ inches long; Day says—'a few inches in length'.

Habitat: Clear streams and rivers of the Terai and Duars. Day gives—'Throughout India and Burma.'

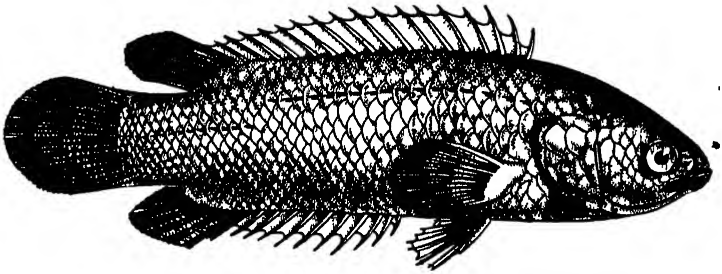
Anabas testudineus (Bloch), *F.B.I.*, No. 1208 ***Anabas scandens.***

The Climbing Perch.

Bengali : *Koi* কই ; Rabha : *Na-kowi* ; Hindi (Bihar) : *Kobhai* कोभाइ.

D. 17-18/8–10. A. 9-10/9–11. L. l. 28–32.

Body oblong, laterally compressed, head wide. A cavity above the gills contains an elaborate respiratory apparatus so that this fish can live for a long time out of water. The lateral line is interrupted at about the 17th scale.



TEXT-FIG. 116.—*Anabas testudineus* (Bloch).

Colour : Greenish-brown, lighter beneath. Traces of four wide vertical bands but not so marked as in *Badis badis* which is rather like this species. Day says the young have a black blotch on side of base of tail, surrounded by a light, sometimes yellow, ring ; usually they have a black spot at the end of the opercle.

Size : Day gives—'Attaining at least 8½ inches'. Our specimens have mostly been small.

Habitat : Streams of the Terai and Duars ; not very common. Day gives—'Estuaries and fresh waters of India, Ceylon, and Burma, the Malay Archipelago and Philippines.'

Habits : This fish is said to travel for some distance on land, and even climb trees. We have not observed this.

Badis badis (Ham.), *F.B.I.*, No. 825 ***Badis buchanani.***

Plate 4, fig. 9.

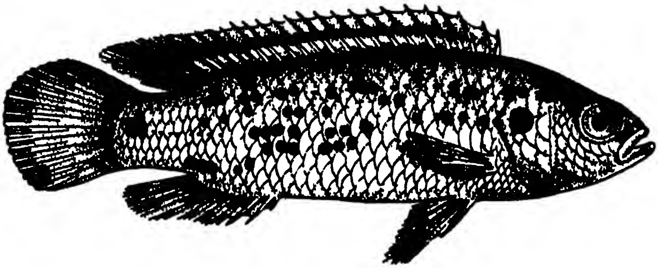
Bengali (local) : *Bot-koi* বট-কই, (Lower Bengal) *Bhedo* ভেদো or *Bheda* ভেদা ; Mechi : *Na-dego* ; Rabha : *Mojipra(p)*.

D. 16-17/7–10. P. 12. A. 3/6–8. C. 16. L. l. 26–33.

The body is an elongated oval, laterally compressed, the head is scaled. The lateral line is placed high on the body but

is interrupted about 8 or 9 scales from the caudal and continues in the usual position on the tail.

Colour: Variable; there are usually a series of darker transverse bands on a ground-colour of dirty red, dark brown or dark green but, in larger fishes especially, the ground-colour is too dark for any bands to be visible. Day mentions bluish-black spots, one on the shoulder, another on the opercle and a third near the base of the caudal, as sometimes occurring. We do not appear to have noticed these. One smallish specimen, from the Apalchand River in the west of the Duars, was very beautifully barred with scarlet and rose pink.



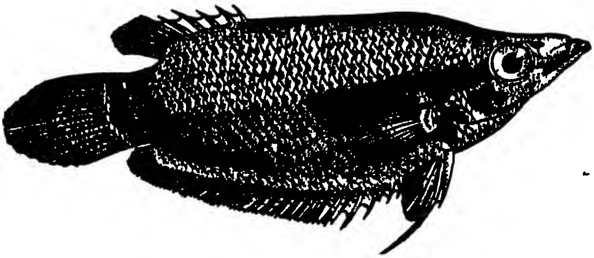
TEXT-FIG. 117.—*Badis badis* (Hamilton).

Size: Day gives—'At least 3½ inches in length' and our largest specimen must have been about this size.

Habitat: Clear streams in the Duars and Terai, *e.g.* the Apalchand River and the Panchenai near the foot of the hills.

Ctenops nobilis McClell., *F.B.I.*, No. 1211 *Osphronemus nobilis*.

D. 5-6/7-8 P. 12. A. 5/23-25. C. 16. L. l. 28-31.



TEXT-FIG. 118.—*Ctenops nobilis* McClelland.

Body deep, laterally compressed, the ventral outline more curved than the dorsal. Snout long and pointed. Mouth small,

oblique, protractile. Dorsal situated in the last third of the body. Outer pelvic ray prolonged into a filament.

Colour: Brown; a silvery white band, usually interrupted, passes from the eye to the middle of the tail. A second, still more interrupted, band from the pectoral along the side and a third along the base of anal. There is sometimes a diffuse black, lighter-edged ocellus at the upper part of the base of caudal.

Size: Day gives—'at least four inches'. We have had them up to 3 inches.

Habitat: Streams of the Duars, not common. We have also seen them for sale in Siliguri bazaar. Day gives—'Rivers of N.E. Bengal and Assam, extending into those of the hills'.

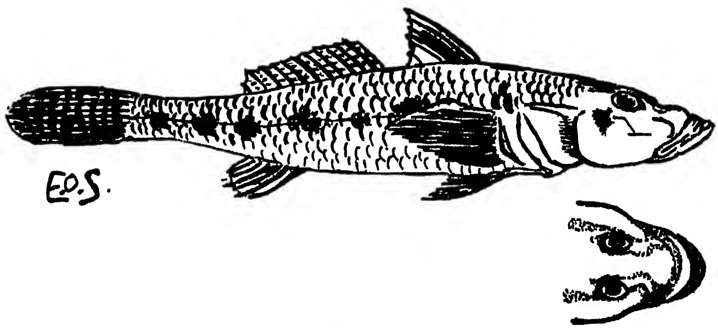
Glossogobius giuris (Ham.), *F.B.I.*, No. 1051 *Gobius giuris*.

Plate 4, fig. 16.

Bengali (local): *Bhalia* ভালা, (Southern Bengal) *Beley* বেলে; Rabha: *Bhal-chata*; Hindi (Bihar): *Bhula* भूला.

D. 6/1/8-9. P. 20. A. 1/8-9. C. 17. L. l. 30–34.

A long, tapering fish, head somewhat compressed vertically. Eyes placed on the top of the head and only $\frac{1}{3}$rd to $\frac{3}{4}$th their diameter apart. Lower jaw the longer. Pelvic fins united forming a disc which is only attached by the base.



TEXT-FIG. 119.—*Glossogobius giuris* (Hamilton).

Colour: Transparent yellowish-grey with vague blotches of sepia along the lateral line. Pelvic fins spotted.

Size: Day says it attains $1\frac{1}{2}$ feet. Our largest was only a few inches long.

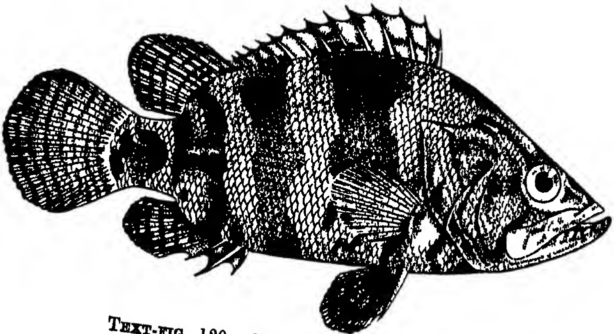
Habitat: Streams of the Terai and Duars, not common.

Nandus nandus (Ham.), *F.B.I.*, No. 827 *Nandus marmoratus*.

Bengali (local): *Dudhurkhal* দুধুরখাল, (Lower Bengal): *Nandus* ন্যাদস্; Mechi: *Thota* or *Na-tika*; Rabha: *Bhaja-budi*.

D. 12–14/11–13. V. 1/5. A. 3/7–9. L. l. 46–57.

A deep, laterally compressed fish with a nearly straight belly and arched back. The snout is pointed and the mouth deep-cleft and very protractile. The lateral line is interrupted at about the 36th scale. Length of head 3, of caudal 5½ and height of body 3-3½ in total length.



TEXT-FIG. 120.—*Nandus nandus* (Hamilton).

Colour: Greenish-brown with brassy reflections, vertically marbled with three broad patchy bands; also a dark blotch on free portion of tail. Narrow bands of spots across fins.

Size: Day gives—'Attains at least 7 inches' and our largest was about this length.

Habitat: Muddy streams and ponds of the Terai and Duars. Day says—'It is common in ditches and inundated fields where it preys on small Cyprinidæ.'

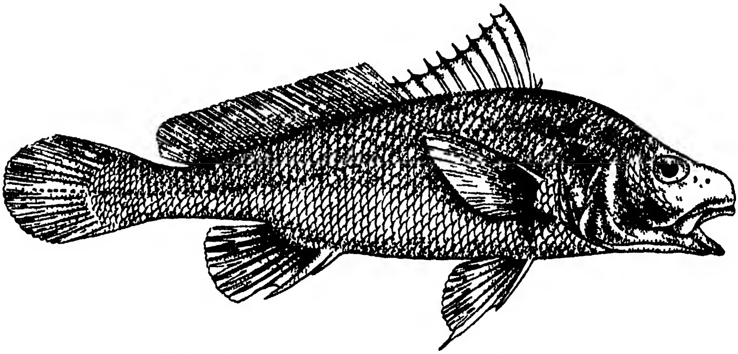
[**Sciæna coitor** (Ham.)], *F.B.I.*, No. 868.

D. 10 | 1-2/26–29. A. 2/7. L. l. 50–55. No barbels.

Body rather elongate, transversely compressed. There are pores round the mouth. No large canine teeth in front of the jaws but an inner row of enlarged teeth in the lower jaw. Caudal wedge-shaped.

Colour: Silvery, anterior part of first dorsal blackish.

Size: Day gives—'Attains a foot in length.' Our only specimen, from Siliguri bazaar, was 7·3 inches.



TEXT-FIG. 121.—*Sciæna coitor* (Hamilton).

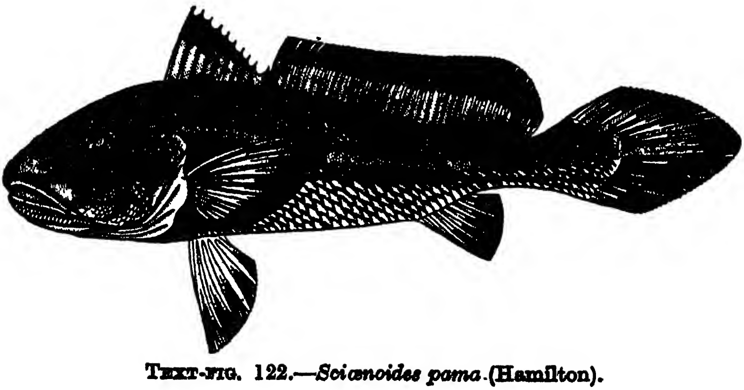
Habitat: Day gives 'throughout the larger rivers of India'. Our specimen was said to have come from Bihar but may have come from the Ganges.

[**Sciænoides pama** (Ham.)], *F.B.I.*, No. 879.

Plate 4, fig. 14.

D. 10 | 1/40–43. A. 2/7. L. l. 55. No barbels.

Body rather elongate, transversely compressed. Upper jaw with an outer row of curved and conical teeth, canine-like anteriorly, not large. Caudal fin tapering to a point.



TEXT-FIG. 122.—*Sciænoides pama*.(Hamilton).

Colour: Light brownish along the back becoming white beneath.

Size : Day gives—' At least 5 feet '. Our solitary specimen, from Siliguri bazaar, was 7½ inches long.

Habitat : Day gives—' Bay of Bengal entering estuaries and rivers as far as the tide extends.' It would be interesting to know where our specimen was caught, as fish are not usually imported from farther afield than the Ganges crossing.

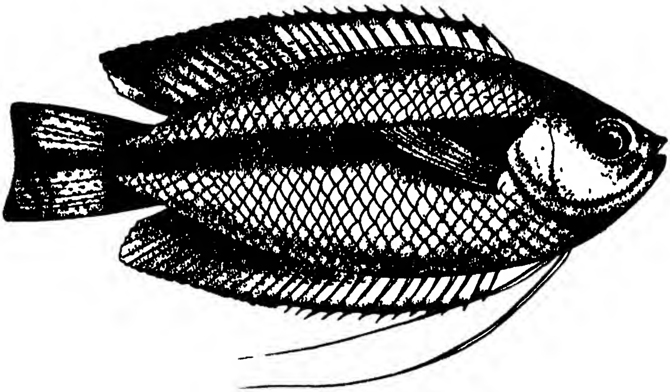
Trichogaster chuna (Ham.), *F.B.I.*, No. 1212.

Bengali : *Chuna khalisha* চুনা খলিশা.

D. 17-18/7-8. P. 9. V. 1. A. 17–20/11–15. L. l. 27–29.

Body deep, compressed ; cleft of mouth small. Each pelvic fin consists of a single, filiform ray. Lateral line interrupted.

Colour : Dull greenish or brownish, lighter along abdomen. A dark band along the side to the lower half of the tail.



TEXT-FIG. 123.—*Trichogaster chuna* (Hamilton).

Size : Day gives—' The largest out of 20 specimens was 1·8 inches long '. Our only specimen was 1·6 inches.

Habitat : The Terai, where we found our only specimen. Day gives—' From the Brahmaputra at Dibrughar, Upper Assam, to the Hooghli at Calcutta.'

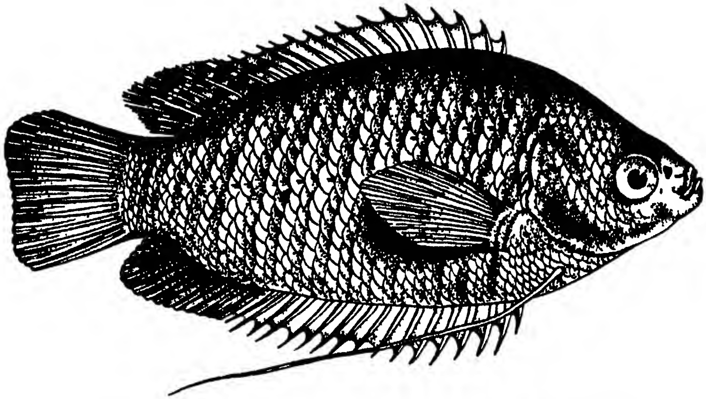
Trichogaster fasciatus Bl. & Schn., *F.B.I.*, No. 1214.

Plate 4, fig. 7.

Bengali : (coloured bands inconspicuous) *Chopra* চোপরা (coloured bands well-marked) *Khalisha* খলিশা, *Cheli* চেলী ; Rabha : *Na-prap*.

D. 15–17/9–13. A. 15–18/14–19. L. l. 29–31.

Body deep, compressed laterally. Cleft of mouth small. Each pelvic fin consists of a single, filiform ray reaching at least to the base of the caudal. Lateral line interrupted.



TEXT-FIG. 124 —*Trichogaster fasciatus* Bloch & Schneider.

Colour · Greenish or bluish above, dirty white below. Fourteen or more orange bands descend obliquely downwards and backwards from the back to the belly with intermediate blue bands which are often more conspicuous. Individual specimens vary from gaily-coloured fish to those in which the bands are hardly noticeable. Day notes a green spot on the gill-cover, pelvic fins edged with red and variegated with black, green, and white, dorsal and caudal spotted with orange and eyes red. He also notes that immature specimens have a black spot at the root of the caudal.

Size : Day gives—'attains 5 inches'. Our largest was about 3 inches long.

Habitat : Clear streams in the Terai and Duars. Day gives—'The Coromandel Coast as far as the river Kistna, the estuaries of the Ganges; Cachar, Assam, Punjab, North-West Provinces, Sind, and Burma.'

Group XI.—THE MURRELS.

This group contains only one Genus in our area—*Ophicephalus*—the snake-headed fishes, best known to anglers by their one sporting member—the *Murrel* (*O. marulius*). All species in this genus have cavities in the head which act as a primitive lung and this enables them to live for a long while out of water.

All the six species in our area are very much alike in shape though differing greatly in colour. For this reason any key to the genus based mainly on shape is less likely to be satisfactory than one based mainly on colour. As, however, it may be necessary to identify a specimen preserved in spirit which will have lost most of its colour, we have given a key of each kind.

KEY BASED MAINLY ON SHAPE.

	O. marulius.	*O. amphibius.*	*O. striatus.*	*O. stewartii.*	*O. gachua.*	*O. punctatus.*
Dorsal rays ..	45–55	51	37–45	39-40	32–37	29–32
Anal rays ..	28–36	34	23–26	26	21–23	21–23
Scales from preopercle to orbit ..	9-10	10	9	5	4-5	5
Scales from snout to dorsal fin ..	15-16	16	18–20	13	12	12
Ratio length of pelvics to pectorals ..	over $\frac{1}{2}$	$\frac{2}{3}$	$\frac{2}{3}$	$\frac{1}{3}$	$\frac{2}{3}$	$\frac{1}{2}$

KEY BASED MAINLY ON COLOUR.

A. Pectorals plain :

(*a*) Ocelli with centre darker and margin lighter than ground colour on lateral line or base of caudal or both—*O. marulius* (p. 122)

(*b*) Belly blue or green, orange bars on flanks *O. amphibius* (p. 119)

(*c*) Blackish above, yellow below, lateral line with peninsulas of the darker colour extending into the yellow *O. striatus* (p. 124)

(*d*) Darker and lighter patches alternating above and below the lateral line, Chin not marbled .. *O. punctatus* (p. 123)

B. Pectorals spotted in zones, darker and ligher patches continuous above and below the lateral line, Chin marbled :—

(*a*) Pelvics $\frac{1}{3}$rd. the length of pectorals ;—circular black spots each occupying part of a scale, base of dorsal iridescent blue in life .. .. .. *O. stewartii* (p. 123)

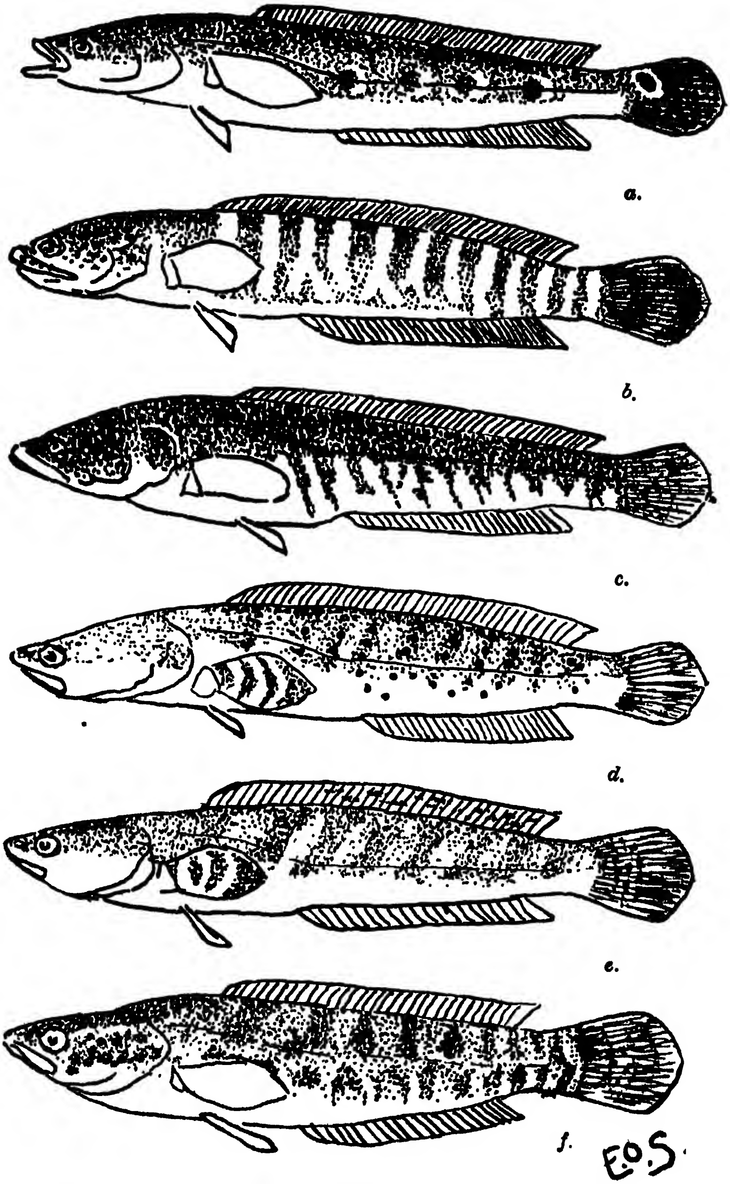
(*b*) Pelvics $\frac{2}{3}$ the length of pectorals ; no black spots—*O. gachua* (p. 121)

Ophicephalus amphibius McClell.

1845. *Ophicephalus amphibeus*, McClelland, *Cal. Jour. Nat. Hist.*, V, p. 275.

Plates 1 and 6.

Note.—McClelland's *O. amphibius* is united with *O. barca* by Day under the latter name. The species here described does not agree with Day's description of *O. barca* but seems to agree, except in colour, with the scanty notes of McClelland's *O. amphibius* given in Day's *Fishes of India.* Dr. Hora is inclined to



Text-fig. 125.—Species of *Ophicephalus* from Northern Bengal. (*a*) *Ophicephalus marulius* Hamilton; (*b*) *O. amphibius* McClelland; (*c*) *O. striatus* Bloch; (*d*) *O. stewartii* Playfair; (*e*) *O. gachua* Hamilton; (*f*) *O. punctatus* Bloch.

agree with Day in uniting the two species but, seeing that our specimens are all from the type locality of McClelland's *O. amphibius* and local names and habits agree, while the colours agree better with *O. amphibius* than with *O. barca* as described by Day, we have ventured to use McClelland's name.

Mechi: *Bora Cheng*; Rabha: *Borna.*

D. 51. P. 17. V. 1/5. A. 34. C. 14. L. l. 78. Barbels 2-retractile.

In shape almost identical with *O. marulius*. A pair of short, retractile, rostral barbels which are absent in the latter species.

Colour: A gorgeously coloured fish. The ground-colour is blue when viewed obliquely and iridescent green when viewed at right angles to the surface. On the body this colour is sprinkled with dark spots, uniform in size but irregular in shape. These spots are absent from the belly, sparse below the lateral line and increasingly plentiful towards the back where they coalesce. On the head the spots are larger and rounded, rich brown below the level of the eye and becoming darker and more plentiful towards the top of the head where they coalesce. The brightest blue (green) and richest brown are in the region of the upper lip. Along the body 13–16 more or less irregular vertical bands about equal in width to the interspaces between them and extending from the dorsal to below the lateral line. These are bright orange bordered with brown and merging into brown on the back and are free from dark spots. The dorsal has the basal half brown or orange, the outer half blue (green), darkening outwards but having a narrow pale blue or white edge. Pectoral deep orange. Pelvics blue. Anal iridescent blue (green) with a narrow dark border. Caudal brown at the base, then iridescent blue (green) with dark rays, then blackish with a narrow white or bluish-white border.

Size: Our longest was 18·4 inches.

Habitat: Russell obtained his specimens in the vicinity of the Chel River about 1845 and gave them to McClelland. Our specimens all come from this vicinity but Dent, who obtained these specimens, has subsequently received reports from Rabhas living immediately east of the Torsa which indicate that the species is found there also.

Habits: The young are found, during the rains, in flooded paddy-fields enclosed by forest. The villagers catch them and put them in their wells to grow. Large fish are found in water-pockets in the beds of dried-up streams in the forest. Russell records that they are found in holes as much as two miles from the river.

Ophicephalus gachua Ham., *F.B.I.*, No. 1205.

Bengali: *Cheng* চ্যাং; Nepalese: *Hili* हिलौ; Mechi: *Na-serainiselo*; Rabha: *Na-ram*; Hindi (Bihar); *Chainga* चैंगा.

D. 32–37. P. 15. A. 21–23. C. 12. L. l. 40–45.

Shape similar to that of *O. marulius*, but head scales larger.

Colour: Brown with a series of about eight darker brown bands sloping slightly forward from the vertical between the dorsal ridge and lateral line, sometimes produced below the later. Pectoral fin with three lighter zones alternating with darker. Day gives—'In the young there is often a large ocellus with a light edge on the last five dorsal rays.' We have never found this present.

Size: We have had them up to about 8 inches. Day gives: 'grows to at least 13 inches'.

Habitat: Muddy or clear streams and ponds from 2,000 feet downwards. Day gives—'Fresh waters throughout India, Ceylon, Burma and the Andamans, also near Gwadar on the Mekran Coast.'

Ophicephalus marulius Ham., *F.B.I.*, No. 1198.

The Murrel.

Plate 4, fig. 2.

Bengali (local): *Sāl* শাল, (Lower Bengal): *Gajari* গজারি; Hindi (Bihar): *Bhor* भोर.

D. 45–55. P. 18. A. 28–36. L. l. 60–70. No barbels.

Body sub-cylindrical tapering from the flattened, snake-like head to the rounded caudal.

Colour: Brownish or greenish-grey above, paler beneath. This species is lighter coloured than others in our area. Four or five large ocelli, dark brown with a hinder margin lighter than the ground-colour, on lateral line. These are not present in young fish. A well-marked ocellus, brown surrounded by a ring paler than the ground-colour, on the upper half of the base of caudal. This is not found in some large fish. The pectorals are not spotted or striated. Young fish are shaped like the adults but have a wide, orange-red band down each side.

Size: Day gives:—'attaining as much as 4 feet.' We have seen fish of this size in Siliguri bazaar; those caught on rod and line in our rivers do not ordinarily exceed 1½ feet.

Habitat: Clear rivers of the Terai and Duars especially at their junction with a side stream but always in the neighbourhood of mud or fine sand. Day gives:—'Fresh waters, principally rivers, from Ceylon and India to China'.

Habits: Frequently takes a spoon and still more often dead bait. It can be a good fighting fish but frequently settles on the bottom after a preliminary demonstration on the surface. The mother is said to accompany the young which swim in close formation.

Ophicephalus punctatus Bloch., *F.B.I.*, No. 1206.

Plate 4, fig. 1.

Bengali (local): *Taki* টাকী, (Lower Bengal): *Lata* ল্যাটা; **Rabha**: *Na-taki*.

D. 29–32. P. 17. A. 21–23. C. 12. L. l. 37–40.

Shape very similar to that of *O. marulius*.

Colour: Brown on the back fading to lighter beneath. A series of about eight vertical darker bands above the lateral line alternating with a similar series below it. The last band before the caudal is continuous above and below the lateral line. Pectorals not spotted or striated.

Size: We have had them up to 7 inches long. Day gives—'up to a foot'.

Habitat: Streams in the hills up to 2,000 ft., muddy streams and tanks in the Terai and Duars. Day gives—'Fresh waters generally in the plains of India, stagnant preferred to running'.

Habits: Day, quoting Günther in Ceylon, records that a female was taken in February containing 4,700 large, besides some smaller, ova.

Ophicephalus stewartii Playfair, *F.B.I.*, No. 1204.

Plate 4, fig. 3.

Bengali: *Dudu-cheng* দুধুচাং, or *Tel-cheng* তেলচাং; Rabha: *Na-ram*.

D. 39-40. P. 17. V. 6. A. 27. C. 14. L. l. 45–50.

Shape similar to *O. marulius*, but the scales on the head are much larger.

Colour: Dark brown on the back fading to lighter on sides and belly. A series of about eight indistinct darker bands sloping forwards are generally visible above the lateral line and for a short distance below it. Some scales have a well-defined, circular, black spot. These spots are more plentiful above the lateral line where they roughly follow the darker bands. Below the lateral line they are fewer and more regularly arranged. The dorsal has a deep blue iridescence along its base, during life, and is white or white and orange along its outer edge. The chin is marbled and the pectorals spotted in zones.

Size: We have found them up to 18 inches. Day gives—'growing to about 10 inches'.

Habitat: Clear streams in the forests of the Duars. Day gives—'Cachar and Assam, in both running and standing water'.

Ophicephalus striatus Bloch., *F.B.I.*, No. 1203.

Plate 4, fig. 4.

Bengali : *Shōl* শোল ; Hindi (Bihar) : *Sowra* सौरा.

D. 37–45. A. 23–26. L. l. 50–59.

In shape this fish resembles *O. marulius*.

Colour : Very dark brown above the lateral line, this colour continuing below this line in irregularly-shaped streaks, roughly parallel and a little off the vertical (the upper end in advance of the lower). The rest of the lower half yellow or orange. The pectoral not spotted or striated. The young are orange-red, when 2 or 3 inches long.

Size : Our longest just over 2 feet. Day gives—' three feet or more '.

Habitat : Muddy rivers and tanks in the Terai and Duars. Day gives—' Fresh waters throughout the plains of India, Ceylon, Burma, China and the Philippines, especially delighting in swamps and grassy tanks '.

Habits : Dent says—' The young, 2 or 3 inches long, are orange-red in colour. On a flooded paddy-field, where the water is 2-3 feet deep, I have seen a mass of probably one or two hundred swimming all herded together like tadpoles. Although I have not actually seen the parent fish myself, all the local busti-wallahs assure me that the mother is always close by and will protect the young from danger.' Day says—' These fishes take a bait very readily, especially a frog, and are said to rise to a salmon-fly '.

Group XII.—THE GLOBE-FISH.

Tetraodon cutcutia Ham., *F.B.I.*, No. 1406.

The Globe-Fish.

Plate 4, figs. 12 and 13.

Bengali (North Bengal) : *Tepa* টেপা, (South) *Potka* পটকা ; Rabha : *Gangthopa* ; Hindi (Bihar) : Phukcha फुकचा.

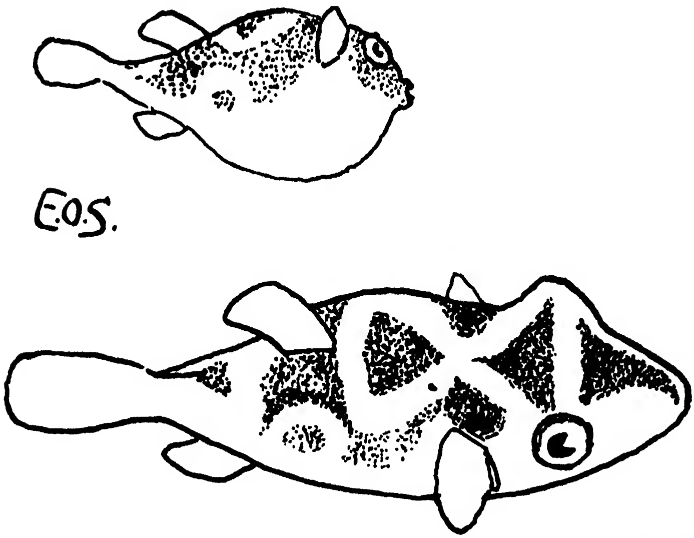
D. 10-11. P. 21. A. 10. C. 7.

Back broad, tapering rather abruptly to the tail. The fins are all rounded. There are no pelvic fins. Eyes large.

Colour : On the upper surface the pattern is in two shades, a lighter (moss-green, minutely mottled) and a darker (greyish-brown or black). The head is dark with one or more transverse light bars across the snout and another joining the eyes. The

light bar between the eyes forms the base of a dark triangle, the apex pointing backwards. A more or less triangular patch above each pectoral and a larger and denser one half way between the pectoral and dorsal. The apices of these four rough triangles are directed towards a point in the back mid-way between the pectorals forming a diagonal cross when viewed from above. Behind the dorsal the pattern is less definite except for a well-marked ocellus (dark centre with a light ring surrounding it) about where the lateral line might be expected to be and just above the anal. The chin and under side of the tail pearl grey; the remainder of the under surface white. The iris is golden yellow.

Size—Day gives: 'attaining about 3½ inches' and we have had them up to about this size.



TEXT-FIG. 126.—*Tetraodon cutcutia* Hamilton. The upper figure represents the fish when inflated. The lower shows the dorsal surface and side.

Habitat: Slow-flowing, clear streams in the Terai and Duars. Day gives—'Fresh waters of Orissa, Bengal, and Assam'.

Habits: When taken from the water they usually distend the œsophagus enormously with air so as to become co-spherical except for the short tail. In the water they constantly vibrate the pectoral, even when stationary, and appear to swim with the pectorals and dorsal only, often holding the tail on one side.

Group XIII.—THE SPINY EELS.

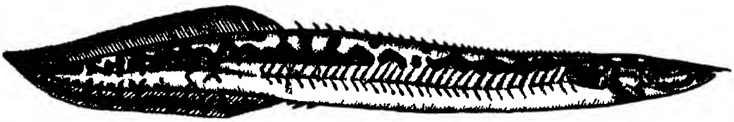
Mastacembelus armatus (Lacép.), *F.B.I.*, No. 1159.

The Spiny Eel.

Bengali (Northern Bengal): *Bām* বাম, (Southern Bengal) *Bheim* ভাঁইম্; Nepali: *Chusi-bam* चुसीबाम; Rabha: *Na-kraing*; Hindi (Bihar): *Bami* बामी.

D. 32–39/74–90. P. 23. A. 3/75–88.

An eel-shaped fish tapering to head and tail. Snout as in *M. pancalus.* The vertical fins are confluent. No pelvic fins.



TEXT-FIG. 127.—*Mastacembelus armatus* (Lacépède).

Colour: Rich brown above, paler beneath. An undulating pattern in dark brown between the lateral line and the dorsal ridge is usually more pronounced posteriorly. It is sometimes produced forward as a blackish line through the eye.

Size: Usually a larger fish than *M. pancalus* and 'attains two feet or more'. (*Day*) The largest we have found was about a foot long.

Habitat: Clear streams throughout the Tarai and Duars. Day gives—'From Sind, throughout the fresh and brackish waters of the plains and hills of India, Ceylon and Burma to China'.

Mastacembelus pancalus (Ham.), *F.B.I.*, No. 1158.

The Smaller Spiny Eel.

Bengali (local): *Turi* তুরী, (Lower Bengal): *Pañkal* পাঁকাল; Rabha: *Thuri-bandha*; Hindi (Bihar): *Gaincha* गैंचा.

D. 24–26/30–42. P. 19. A. 3/31–46. C. 12.

TEXT-FIG. 128.—*Mastacembelus pancalus* (Hamilton).

An eel-shaped fish tapering to head and tail. Scales minute. The long, fleshy snout has a tri-lobed extremity with a concave,

but not striated, lower surface. The first dorsal consists of free spines, increasing in length posteriorly. The soft dorsal and anal are separated from the caudal by a small notch. No pelvic fins.

Colour: Greenish olive along the back, yellowish beneath; fins yellow with black spots.

Size: Day gives—'at least 7 inches'. Our longest was about half this size.

Habitat: Streams of the Terai and Duars. Day gives—'Large rivers of India and localities near the sea'.

Rhynchobdella aculeata (Bloch), *F.B.I.*, No. 1155.

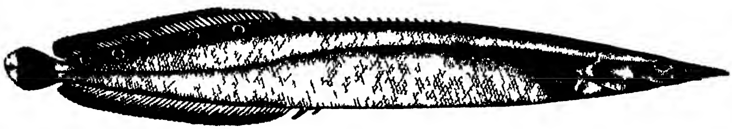
Plate 4, fig. 8.

Bengali: *Goichi* গইচী; Hindi (Bihar): *Patgaincha* पतगैंचा.

D. 1–20/44–54. P. 23. A. 0–3/44–52. C. 15.

An eel-shaped fish tapering to head and tail. Scales minute but lateral line well-marked.

The long, fleshy snout has a tri-lobed extremity with a concave, striated lower surface, the lower jaw being much shorter. Teeth minute. The first dorsal consists of free spines, 16–20 in number according to Day, but one large specimen which we obtained from the Magurmari River (Apalchand Forest, in the west of the Duars) differed from the rest in having only one external dorsal spine and no anal spines. We at first took this to be a new species but Dr. Hora, on dissection, found traces of the usual number of spines beneath the skin. Dorsal and anal fins not confluent with the caudal. No pelvic fins.



TEXT-FIG. 129.—*Rhynchobdella aculeata* (Bloch).

Colour: Greenish or brownish-grey above fading to yellowish beneath, almost uniform with the exception of a faintly lighter longitudinal band between the lateral line and dorsal ridge extending from the base of the caudal fin, over the eye, to half way along the snout. Fins light brown with darker mottling. Some specimens, usually the smaller ones, have a series of 3 to 9 large black ocelli, having a white or buff edge, along the base of the dorsal.

Size: Day gives—'Attaining 15 inches' our longest 14 inches.

Habitat: Most of our specimens were from muddy streams in the Apalchand Forest in the west of the Duars. Day gives—

'Brackish waters within tidal influence' but Inglis says it is common in Bihar where it is known as *Patgaincha*.

Group XIV.—THE MUD EEL.

Amphipnous cuchia (Ham.), *F.B.I.*, No. 70.

Bengali : *Kuchia* or *Kuṅche* কুচিয়া or কুঁচে.

D. very rudimentary ; P., V., A., and C. absent.

An eel-shaped fish with a tapering tail which is flattened in a vertical plane.

Fins : The only fin, the dorsal, is situated just in front of a vertical from the vent.

Scales : Distinct and longitudinally arranged.

TEXT-FIG. 130.—*Amphipnous cuchia* (Hamilton).

Colour : Dark brown above with numerous still darker spots ; orange-brown without spots beneath.

Size : Our longest specimen was 2 feet.

Habitat : Mud holes in paddy fields in the Duars and Terai. Day gives—'Fresh and brackish waters of the Punjab, Bengal, 'Orissa, Assam, and Burma'.

Habits : Hamilton writes : 'Natives reject it 'as food and imagine that its bite is fatal to cattle, although less 'powerful on the human kind—a supposition highly improbable'. It is sold and eaten in the Duars and we have seen it handled quite freely, in fact the only way to catch it is to grope for it with the hands in mud.

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II. Names in Bengali Script.

III. NAMES IN HINDI SCRIPT.

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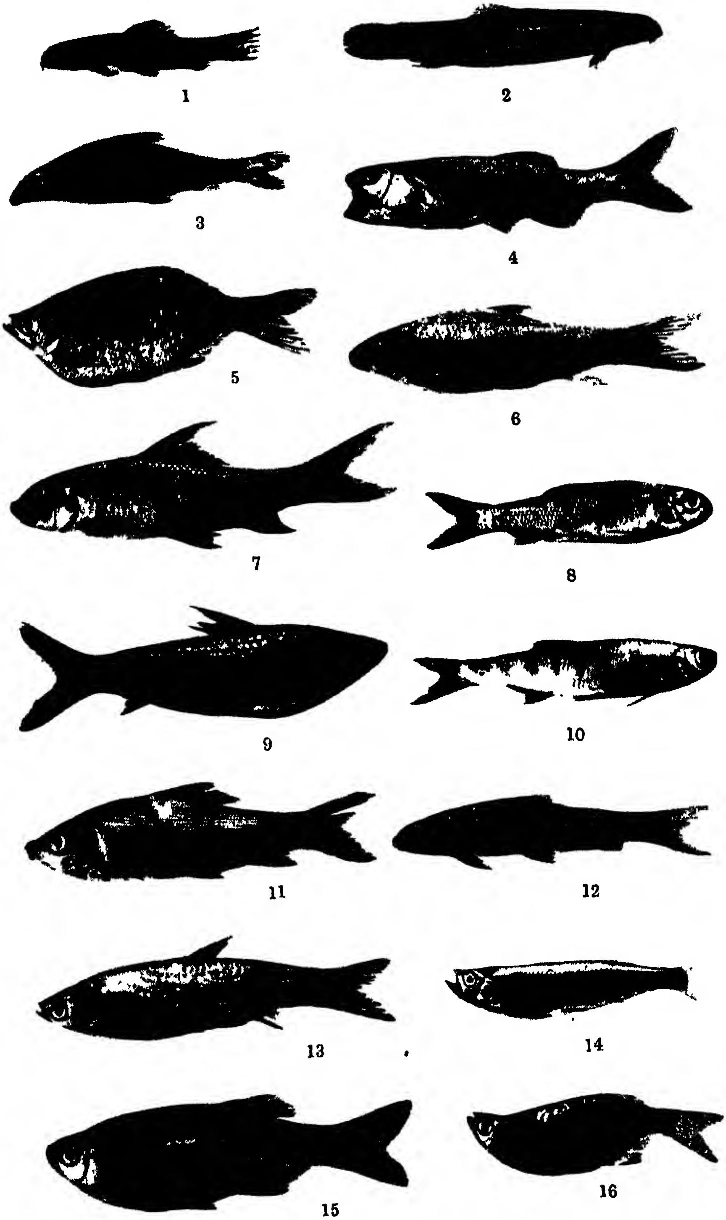
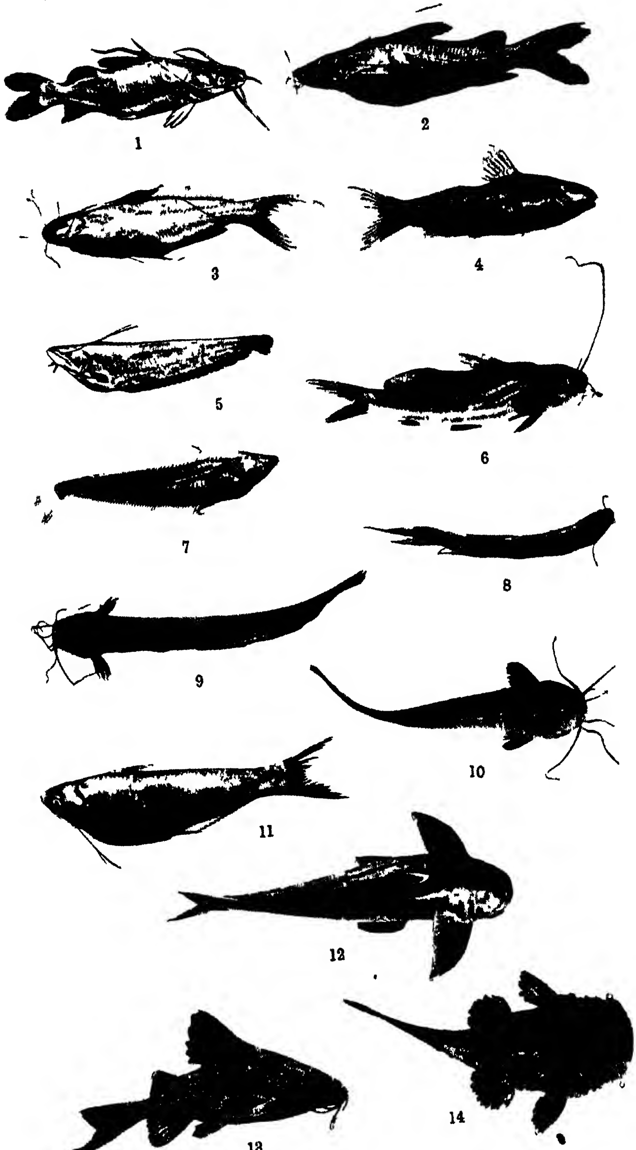
,, 2.—*Lepidocephalichthys guntea* (Hamilton).
,, 3.—*Psilorhynchus balitora* (Hamilton).
,, 4.—*Barilius shacra* Hamilton.
,, 5.—*Danio devario* Hamilton.
,, 6.—*Labeo pangusia* (Hamilton).
,, 7.—*Labeo dero* (Hamilton).
,, 8.—*Aspidoparia jaya* (Hamilton).
,, 9.—*Cirrhina reba* (Hamilton).
,, 10.—*Barilius vagra* Hamilton.
,, 11.—*Labeo gonius* (Hamilton).
,, 12.—*Crossocheilus latia* (Hamilton)
,, 13.—*Rasbora elenga* (Hamilton).
,, 14.—*Chela bacaila* Hamilton.
,, 15.—*Danio aequipinnatus* (McClelland).
,, 16.—*Laubuca laubuca* (Hamilton).



FISHES OF NORTHERN BENGAL.

EXPLANATION TO PLATE 3.

FIG. 1.—*Mystus seenghala* (Sykes).
,, 2.—*Mystus menoda* (Hamilton).
,, 3.—*Mystus cavasius* (Hamilton).
,, 4.—*Leiocassis rama* (Hamilton).
,, 5.—*Wallago attu* (Bloch & Schneider).
,, 6.—*Mystus bleekeri* (Day).
,, 7.—*Callichrous pabda* Hamilton.
,, 8.—*Olyra kempi* Chaudhuri.
,, 9. *Heteropneustes fossilis* (Bloch).
,, 10.—*Clarias batrachus* (Linnaeus).
,, 11.—*Pseudeutropius garua* (Hamilton).
,, 12.—*Pseudecheneis sulcatus* (McClelland).
,, 13. *Erethistes hara* (Hamilton).
,, 14.—*Chaca chaca* (Hamilton).



FISHES OF NORTHERN BENGAL.

Explanation to Plate 4.

Fig. 1. -*Ophicephalus punctatus* Bloch.
,, 2. –*Ophicephalus marulius* Hamilton.
,, 3. *Ophicephalus stewartii* Playfair.
,, 4. *Ophicephalus striatus* Bloch.
,, 5. -*Notopterus chitala* (Hamilton).
,, 6. –*Notopterus notopterus* (Pallas).
,, 7.– *Trichogaster fasciatus* (Bloch & Schneider).
,, 8. *Rhynchobdella aculeata* (Bloch).
,, 9. *Badis badis* (Hamilton).
,, 10. – *Doryichthys deocata* (Hamilton). Female.
,, 11. *Dorichthys deocata* (Hamilton). Male.
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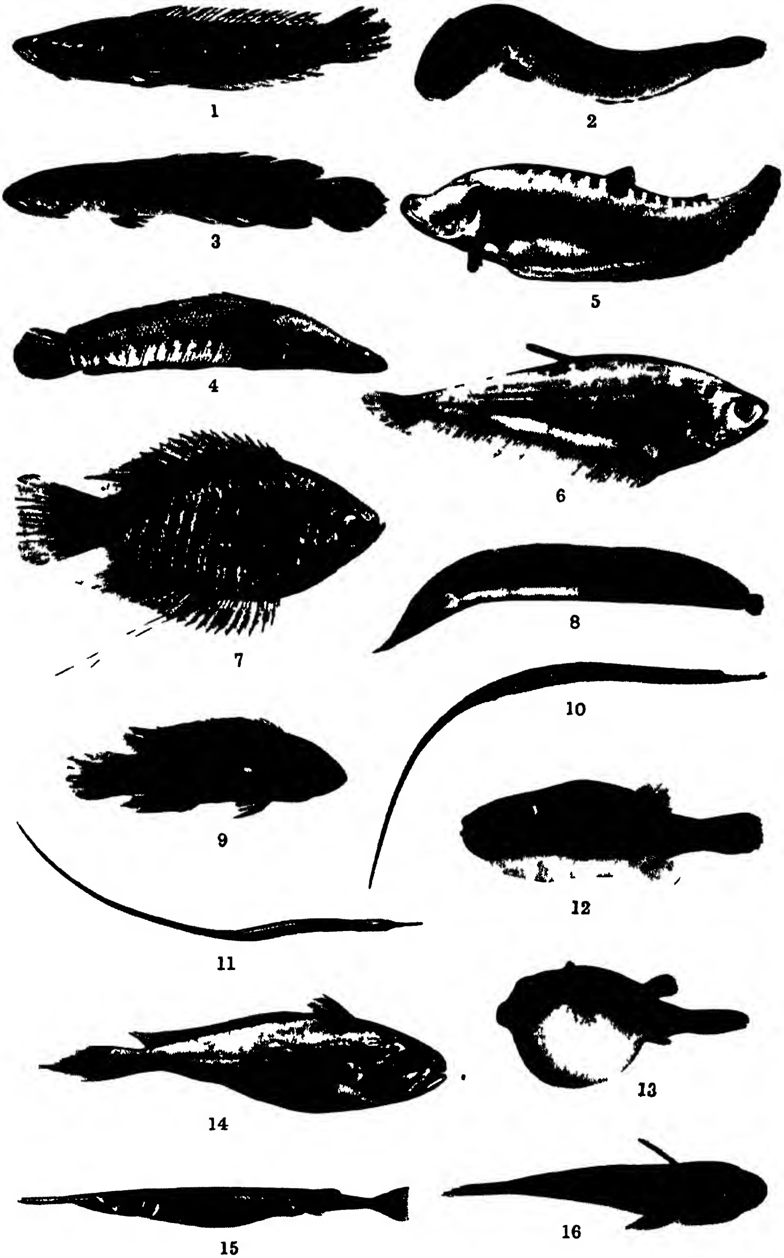
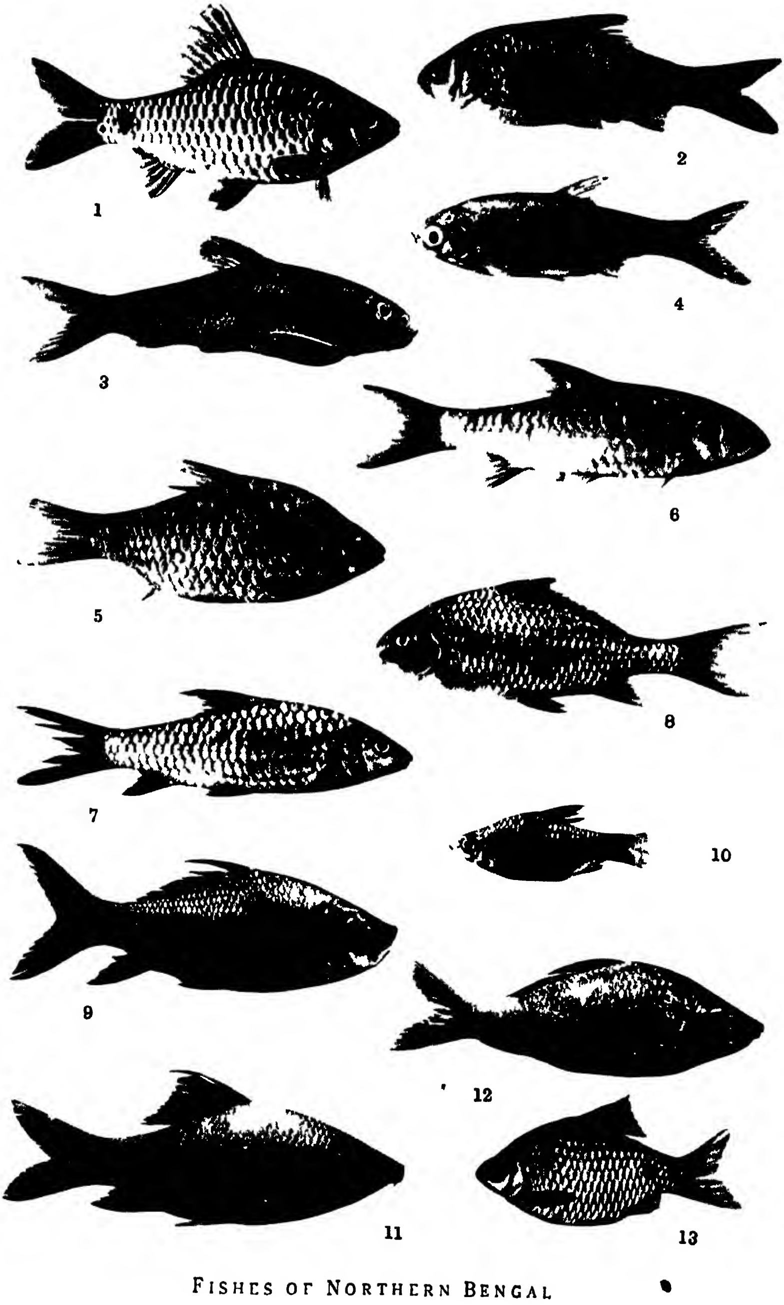
,, 13.—*Tetraodon cutcutia* Hamilton. When taken out of water.
,, 14. – *Sciaenoides pama* (Hamilton).
,, 15. –*Xenentodon cancila* (Hamilton).
,, 16.– *Glossogobius giuris* (Hamilton).



FISHES OI NORTHERN BENGAL.

Explanation to Plate 5.

Fig. 1.—*Barbus stigma* (Cuvier & Valenciennes).
,, 2. *Barbus sarana* (Hamilton).
,, 3.—*Barbus chagunio* (Hamilton).
,, 4.—*Amblypharyngodon mola* (Hamilton).
,, 5.—*Barbus titius* (Hamilton).
,, 6.—*Lissocheilus dukai* (Day).
,, 7.—*Barbus putitora* (Hamilton).
,, 8.—*Semiplotus semiplotus* (McClelland).
,, 9.—*Catla catla* (Hamilton).
,, 10.—*Barbus ticto* (Hamilton).
,, 11.—*Labeo calbasu* (Hamilton).
,, 12.—*Labeo nandina* (Hamilton).
,, 13.—*Barbus conchonius* (Hamilton).



FISHES OF NORTHERN BENGAL

Ophicephalus amphibius McClelland

Journal Royal Asiatic Society of Bengal. Science.

Volume IV, 1938.

ARTICLE NO. 1.

The Histology and Physiology of the Intestine and Hepato-pancreas of two Isopods, *Ligia exotica* Roux, and *Armadillio elevatus* Verhoeff.

By MARY CHANDY.

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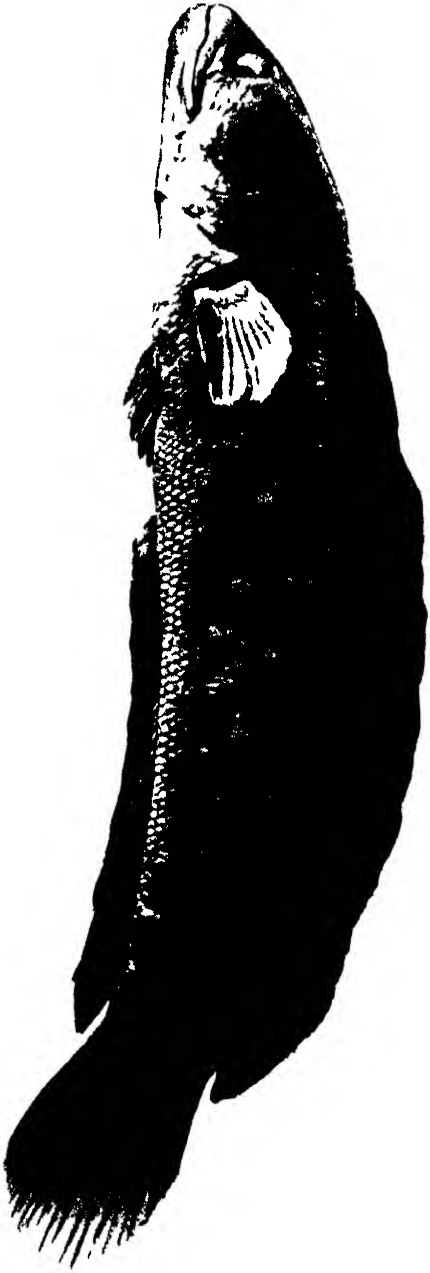
The histology of the digestive organs of Isopods has engaged the attention of several zoologists like Mayer (1879), Webber (1880), Huet (1885), Rosenstadt (1888), Ide (1892), McMurrich (1898), Murlin (1902), Apathy (1908), Jordan (1913), Nusbaum (1917–1920), Patrick (1927) and Nicholls (1931). They have made valuable contributions towards the elucidation of the problems of secretion, digestion, and absorption in the alimentary tract. But in the light of recent advances in cytology many points still remain to be elucidated, especially the secretory phenomena in the glandular cells of the hepato-pancreas. This aspect of the problem and the study of the cells in the living condition have been the chief interest in my work.

The specimens chosen for study were *Ligia exotica* Roux and *Armadillio elevatus* Verhoeff. The former is a common brackish water form of the Coovum River, Madras and is practically adapted for life on land, for it can live out of water for long hours. It is usually found crawling on the wet muddy banks of the river and its canals or clinging to the keels of boats. It is omnivorous in diet, and in the laboratory has been noted to eat even cork and sponge that were used as mere substrata for it to live on. *Armadillio* is a purely terrestrial form and lives under stones or decaying vegetable matter and feeds on organic débris



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2. The Anatomy of the Digestive Organs.

In both *Ligia* and *Armadillio* the alimentary canal is a straight tube, running through the middle of the body-cavity. The mouth is ventral in position and opens into the narrow oesophagus which dilates to form the so-called 'stomach' or the main part of the fore-gut. The fore-gut passes imperceptibly into the intestine. At the junction of the fore-gut and the intestine, in the mid-ventral line, opens the common median duct of the moniliform hepato-pancreatic glands of which there are three pairs in *Ligia* and two in *Armadillio* extending the whole length of the body-cavity and practically enveloping the intestine (fig. 1, a. and b.).

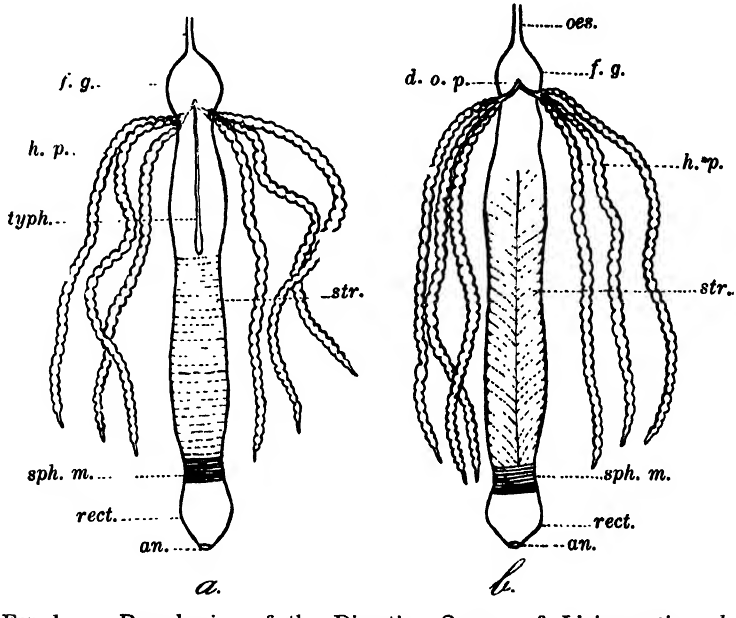

Fig. 1. *a*, Dorsal view of the Digestive Organs of *Ligia exotica*. *b*, Ventral view of the same. *an.*, anus; *d.o.p.*, dorsal opening of the common duct of hepato-pancreatic tubules; *f.g.*, fore-gut; *h.p.*, hepato-pancreas; *oes.*, oesophagus; *rect.*, rectum; *sph.m.*, sphincter muscle; *str.*, stratification of epithelium; *typh.*, typhlosole. (×cir. 2½).

The intestine is a straight tube which presents special features along its dorsal and ventral aspects. The dorsal surface in both the genera is marked by a groove, more prominent in *Armadillio* than in *Ligia*. This groove extends from the anterior end to about half the length of the intestine in *Ligia* (fig. 1, a) and three-quarters in *Armadillio* (figs. 4 and 5) indicating an internal folding of the intestinal epithelium or the *typhlosole*.

In *Ligia* the epithelium of the posterior half of the intestine is disposed biserially on either side of the mid-ventral line, giving it a characteristic pinnate appearance externally (fig. 1, b). The terminal portion of the intestine is marked by the presence of an extensive thick sphincter muscle, beyond which the intestine dilates into the rectum and opens to the outside through the anus.

The part of the gut between the opening of the hepato-pancreas and the beginning of the rectum is usually termed the 'midgut' in Isopods, but it is a misnomer since this part of the alimentary canal is not endodermal in origin. Embryological work on Isopods has shown that 'the digestive tract is formed almost entirely from two ectodermal invaginations (viz. the stomodaeal and the proctodæal), the mesenteron being represented principally by the hepato-pancreatic lobes, only a very small portion of the intestine, just where the hepato-pancreatic lobes unite with it, being possibly endodermal' (10, 1895).

3. The Histology and Cytology of the Intestine and the Hepato-pancreas.

(a) *The Intestine.*

To study the histology of the digestive system, the animals were dissected alive in a fixing fluid or in normal saline, so that very little time was allowed for post-mortem changes. Bouin's, Carnoy and Corrosive sublimate were used as fixatives and these with Iron-hæmatoxylin invariably gave excellent results. For a more detailed study of cell-inclusions, Flemming's, Champy Kull, Ciaccio's, Da Fano, Nassanov, and Weigel's modification of Mann Kopsch were employed with satisfactory results.

Nicholls describes in full detail the fore-gut of *Ligia oceanica* (12, 1931). He finds that this chamber is equipped with a complicated armature of ampullæ and lamellæ for the extraction of liquid food, and that it has a filtering apparatus to strain the liquefied filtrate from the solid particles. He further adds that in *Ligia oceanica* the intestine and hepato-pancreas can absorb only liquefied food, a point which has been confirmed by me in *Ligia exotica*.

The fore-gut passes into the intestine which possesses the typhlosole in its anterior region. In a transverse section, the wall of the intestine presents the following layers beginning from the coelomic side (figs. 2 and 3) : (1) a discontinuous layer of longitudinal muscle-fibres, (2) a continuous layer of circular muscle-fibres, (3) a thin basement membrane, (4) the intestinal epithelium, and (5) a thick internal cuticular layer or intima.

The muscular layers are not sharply marked off; as a matter of fact, both the longitudinal and circular layers usually interlace so that it is difficult to make out their independent

existence. The basement membrane is thin but very definite. The epithelium forms the most important layer and is made up of a single layer of cells. The cells are demarcated by large

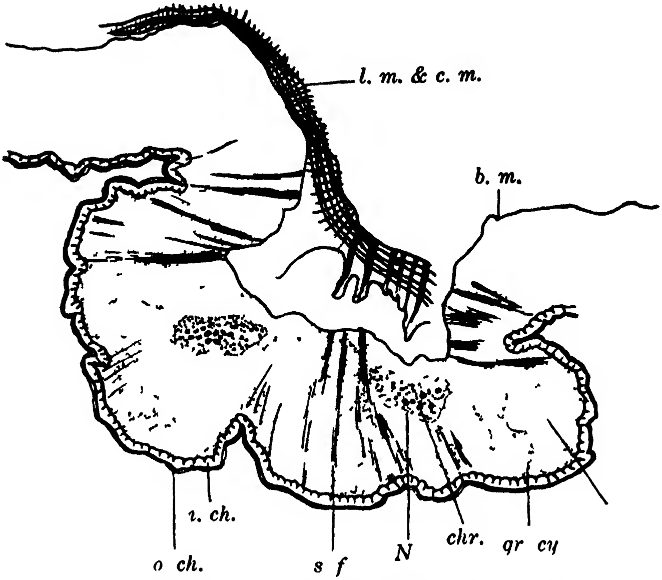

FIG. 2 A transverse section of the typhlosolar region of the intestine of *Ligia exotica*. *b.m.*, basement membrane, *c.m*, circular muscles, *gr.cy.*, granular cytoplasm; *i.ch.*, inner chitin, *l.m.*, longitudinal muscles, *N.*, nucleus, *o.ch.*, outer chitin, *s f.*, supportive fibres; *vac.*, vacuoles. (×600).

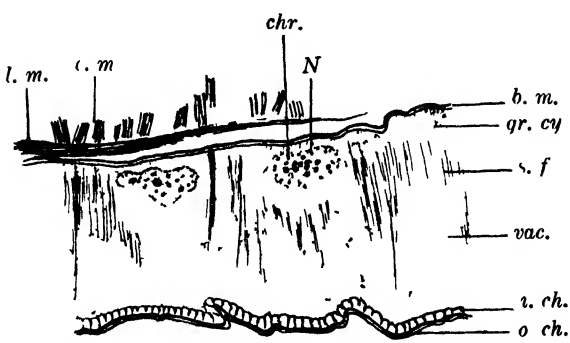

FIG. 3. A transverse section of the intestine of *Armadillo* to show details of histology. Letters as in fig. 2. (×600).

nuclei, the intervening cell-walls being absent. This feature had been observed by previous workers like McMurrich and Murlin in

other Isopods also, and they have described the epithelium as a '*syncytium*'—a feature undoubtedly present in *Ligia* and *Armadillio*.

The structure of the intestine in *Ligia* and *Armadillio* presents several interesting features. Firstly, the typhlosole is most prominent in *Armadillio* and forms an infolding of the epithelium, extending laterally on either side into the lumen of the intestine like two horns (fig. 5); in *Ligia exotica*, on the other hand, the typhlosole is poorly developed (fig. 2). Secondly, the relative thickness of the epithelium varies in the two genera: in *Armadillio* the intestinal epithelium at the anterior end of the mid-gut is thinner on the dorsal and lateral sides, but enormously thicker on the ventral wall, about three times as thick (fig. 5). Posteriorly this thickness diminishes gradually till the epithelium on all sides is of a uniform thickness. The significance of this variation is not well understood; perhaps it is correlated with the greater degree of absorption in the anterior region. In *Ligia* the dorsal region of the intestinal epithelium is thrown into folds on either side of the typhlosole but there is no marked difference in the thickness of the cells in this region. Posterior to the typhlosole, however, there is a ventral groove, which is easily visible on a dissection of the entire gut. This groove is formed by a curving in of the intestinal wall, the cells on either side being longer and closely packed, thus giving a characteristic pinnate appearance externally.

In the syncytial epithelium of the intestine, the distribution of nuclei shows very clearly the cellular limits. In many places the basement membrane is lifted up between the two neighbouring cells and the internal cuticular lining of the cells is drawn in between the two adjacent cells. The epithelium is further characterized by the presence of 'supportive fibres'—'longitudinal thickenings of the cytoplasm—running from the basement membrane to the cuticular layer, which are all that suggest something of the nature of the cell-walls, but are indeed more (numerous ?) than the nuclei' McMurrich (10, 1898). The supportive fibres are disposed in bundles and are abundant in the typhlosolar region. In between the fibres the cytoplasm is granular and big vacuoles are seen prominently towards the intima. It is possible that both vacuoles and granules may be concerned with absorption in the intestine. The nuclei are large and spherical, often oblong and even amœboid, with a clear nuclear membrane and a large number of chromatin granules. The nucleoli are also seen in a few cells.

The internal cuticle is surprisingly thick but without pores, although Murlin (11, 1902) is of opinion that in land Isopods the intima is provided with microscopic pores, while McMurrich and Nicholls failed to establish the occurrence of these pores. I agree with the two latter authors, as I have also failed to see any pores in my numerous preparations. The cuticle is definitely

composed of two layers, of which the inner is thicker and contains many closely set cavities, while the outer is thinner and homogeneous.

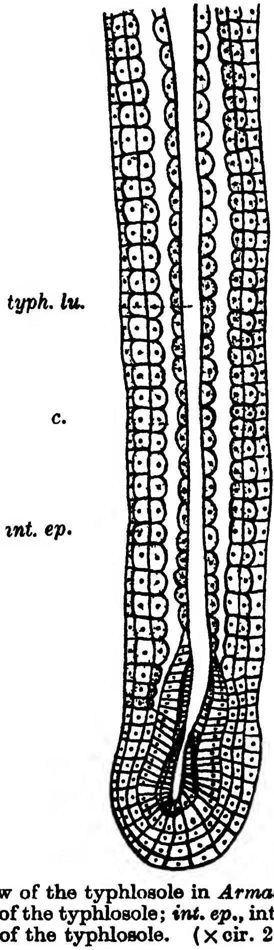

FIG. 4. A surface view of the typhlosole in *Armadillio*. *c.*, cells bordering the groove of the typhlosole; *int. ep.*, intestinal epithelium; *typh. lu.*, lumen of the typhlosole. (× cir. 26).

An interesting but obscure feature of the histology of the gut is that both in *Ligia* and *Armadillio* certain structures called 'blisters' are present on the wall of the gut. These are found usually in animals which have had a good meal before being killed. On sectioning the intestines of such forms, it is observed that the intestinal epithelium undergoes profound changes in the blistered portions. The internal cuticular layer gets separated off from the overlying cytoplasm which is filled up

with densely crowded and deeply staining granules. The supportive fibres are very scanty or even absent, and when present are found to be attached to the basement membrane alone in broken bits. The nuclei are unaffected and either occupy the

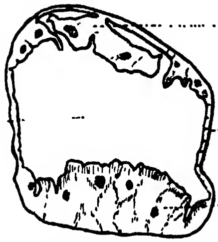

FIG. 5. A transverse section of the intestine of *Armadillio*. *l.*, lumen of the intestine ; *lat.w.*, lateral wall of the intestinal epithelium ; *typh.*, typhlosole; *v.ep.*, ventral epithelium. (×266).

usual basal position or move up to the luminal border. The great increase in the granules of the cytoplasm and the absence of supportive fibres are notable features and are undoubtedly related to some phase of absorption by the cytoplasm, 'the true significance of which is not understood yet' (12, 1931). Nicholls reports the same phenomenon in *Ligia oceanica* and it is stated that in the intestine of insects this is a phenomenon of common occurrence (Imms) and in fact in all articulated animals (Pavlovsky).

(*b*) *The Hepato-pancreas.*

A study of transverse sections (figs. 7 and 8) shows that the hepato-pancreatic cells are supported by a basement membrane and are surrounded by a muscular layer which controls the rhythmic movements of the glands. Externally each tubule is protected by a serous membrane which is thin and structureless and often peels off from the underlying layers in fixation.

The hepato-pancreatic gland consists of two types of cells: (1) tall columnar cells which are found in large numbers, and (2) wedge-shaped cells, which are small in numbers and are distributed among the cells of the first type. Each cell has its own thick cuticular wall, the chitinous nature of which has been verified by Patrick (14, 1927) by using the specific test of Pantin and Rogers for chitin.

The tall columnar cells have narrow bases where the nuclei are lodged. The nucleus is large and has a clear definite nuclear membrane; the chromatin granules are large and numerous; the nucleoli are prominent, their number varying from one to several. The cytoplasm is conspicuously alveolar, the alveoli being of varying sizes, the larger alveoli being found towards the luminal border. In fresh glands these cells are found to contain

yellow oil globules apparently of the nature of fat. On treatment with Sudan iii the yellow globules turned red, thereby showing the lipoidal nature of the globules.

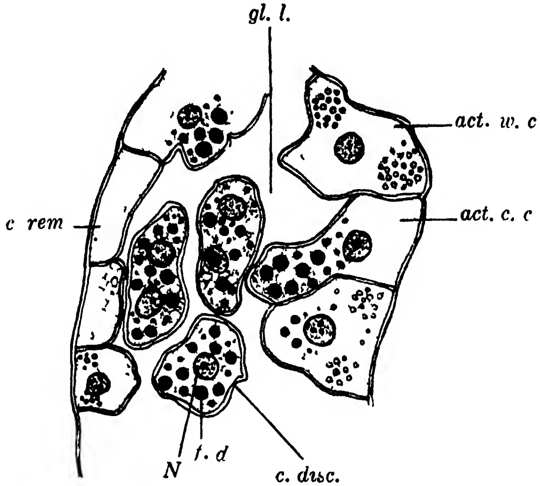

FIG. 6. A transverse section of the hepato-pancreas of *Armadillo* to show lipoidal secretion. *act.c.c.*, active columnar cells; *act.w.c.*, active wedge-shaped cells; *c.disc.*, cells discharged; *c.rem.*, cell-remnant; *f.d.*, fat droplets; *gl.l.*, lumen of gland; *N.*, nucleus. (×266).

In fixatives like Bouin's, Carnoy's and Corrosive sublimate, the vacuoles stand out well-defined. To determine the nature of these vacuoles precisely, tissues were fixed in Flemming and Champy Kull. In these osmic preparations the cytoplasm is found to be loaded with black globules in these vacuolar areas (fig. 8). When treated long with xylol or with turpentine, these black globules dissolve away leaving the vacuoles clear, as in Bouin's and Carnoy's fixatives. The blackening with osmic acid shows the fatty nature of the products in these vacuoles, also the fact that xylol can dissolve the fat shows that this fat is of the neutral type. Therefore these cells are proved to be concerned with the absorption and storage of fat.

As regards the wedge-shaped cells they are found to be more granular in all fixatives as compared with the columnar cells. These granules are finely distributed around the nucleus and stain intensely with Iron-hæmatoxylin. Besides these, larger granules are also present in these cells which are glistening in appearance and are yellowish brown in colour. They hardly take any stain and have been identified as *zymogen granules* of the hepato-pancreas, bodies which are concerned with the production of enzymes (fig. 8). These are very much more

conspicuous in *Armadillio* than in *Ligia*. Perhaps the complete terrestrial habit and consequent change of food may be the reason for increased enzyme production in the former.

Zymogen granules have been detected by Murlin, Mc-Murrich, Frenzel and Nicholls, who all agree in their description of these granules. Patrick too identifies refringent granules in these cells, but comes to the conclusion that they are granules of *mucin* or its precursor *mucigen*. To test the correctness of Patrick's statement histo-chemical test for mucin was employed. Glands were fixed in corrosive sublimate and stained in specific stains for mucin such as Thionin, Toluidin blue, Mucicarmine and Methylene blue. Thionin and Methylene blue gave the best

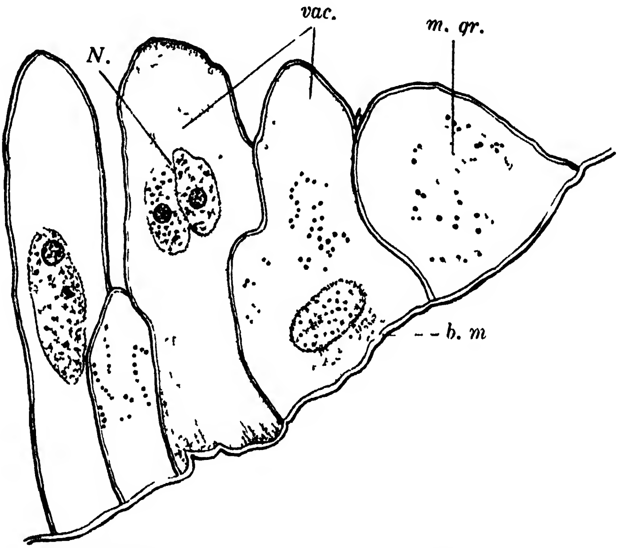

FIG. 7. A transverse section of the hepato-pancreas of *Ligia* (Corrosive sublimate and Methylene blue) *b.m*, basement membrane; *m.gr.*, mucin granules, *N.*, Nucleus; *vac.*, vacuoles. (×600).

positive results, mucin granules being stained reddish purple. It is absolutely clear, therefore, that mucin granules are present in these cells. But are they the yellowish brown, refringent granules of other preparations? To solve this problem, sections of glands in various fixatives were carefully compared. Zymogen granules are found to be best preserved in all osmic preparations, partly in Ciaccio's and hardly in corrosive sublimate. They are formed of complex chemical substances that stain with great difficulty. Acid fuchsin and Methyl green stain them red and they can thus be differentiated from the mitochondria which take up a purple colour with these stains. These observations corro-

borate those of Murlin's. Now, considering that the yellow granules are not preserved by corrosive sublimate, in which mucin specific stains react best, how can Patrick conclude whether they are granules of mucin or mucigen? I have tried to stain the zymogen granules, where they are preserved, in Methylene blue, in which they are found to take up a blue colour, but not the characteristic metachromatic purple stain, which Methylene blue imparts to mucin granules. We come to the problem again. Are both these granules the same, or are they two different inclusions in the hepato-pancreatic cells? My opinion is that they are entirely different cell-inclusions. Mucin is undoubtedly

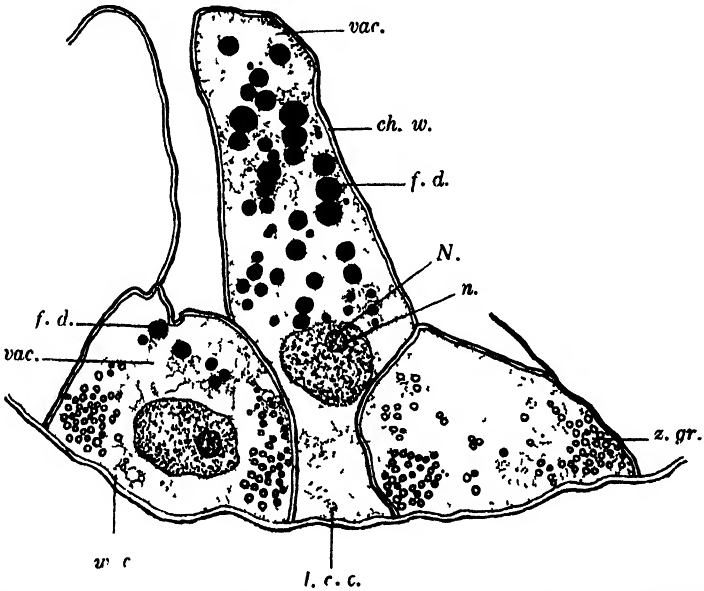

FIG. 8. A transverse section of the hepato-pancreas of *Armadillio* (Champy-Kull and Acid Fuchsin). *ch.w.*, chitinous wall; *f.d.*, fat droplets., *l.c.c.*, large columnar cells, *n.*, nucleoli; *z.gr.*, zymogen granules. (× 600).

produced by the wedge-shaped cells and most probably helps to carry the zymogen granules (fig. 7).

Besides these granules, fat globules are also found occasionally in the wedge-shaped cells both in *Ligia* and *Armadillio*. We have already observed the occurrence of a large amount of fat in the tall columnar cells. What is the origin and distribution of fat in the hepato-pancreas? To settle this point, glands were fixed in Ciaccio's mixture for lipoids and stained in Sudan iii. When examined it was found that lipoidal granules, stained orange-yellow, occur in both columnar and

wedge-shaped cells, showing thereby that both types of cells manufacture lipoids and the distinction as raised by Webber and supported by Patrick is untenable.

Frenzel, Murlin and Nusbaum consider that the smaller cells are the young stages in the cellular growth of hepato-pancreas. The last author thinks that the wedge-shaped cells are more concerned with enzyme production, although fat is also synthesized in them to a small extent, while in the columnar cells, fat accumulates so as to fill up the cells, and that little or no zymogenesis occurs in these cells. My observations confirm these conclusions of Nusbaum.

4. The Physiological Activities of the Intestine and the Hepato-pancreas with special reference to Absorption.

Since both the intestinal epithelium and the cells of the hepato-pancreas are lined with a chitinous cuticle, the problem of absorption has been of great interest to all workers on the digestive system of Isopods. To summarize the work already published on this point we might mention the following:—

(I) McMurrich (1898) is of opinion that the 'midgut' of Isopods does not play any part in absorption but that it serves as a reservoir of food. It is the hepato-pancreas that is both digestive and absorptive, a statement for which he does not adduce any experimental evidence.

(II) Murlin (1902) thinks that the cuticle is porous and gives experimental evidence to show that fat and certain albuminous substances are absorbed through the epithelium of the intestine. He also says that a microscopical study of the absorption of fat indicates that fat is hydrolysed by digestive enzymes and that it is absorbed in the form of cleavage-products and at least partially synthesized into neutral fat under the influence of ferment action. But he also does not adduce any experimental proof.

(III) Nusbaum (1917), by feeding the animals on Ferric peptonate and staining the sections with Potassium ferrocyanide and Hydrochloric acid, found that both the intestine and hepato-pancreas were absorptive.

(IV) Aubery Nicholls (1931) working on *Ligia oceanica* at the Plymouth Laboratory reports that he has been able to demonstrate that the 'midgut' throughout its length and the hepato-pancreas are both absorptive. He followed Yonge's method (1926, *b*) and fed the animals on colloidal iron in the form of Ferrum oxydatum saccharatum. After a given period, the gut and hepato-pancreas were fixed in 5% solution of ammonium sulphide in 90% alcohol, to which an equal quantity of Bouin's fluid was added. The sections were then treated with a 10% aqueous solution of Potassium ferrocyanide followed by a

few minutes in a dilute solution of Hydrochloric acid, and a bright Prussian blue colouration resulted wherever the colloidal iron had been absorbed. In the hepato-pancreas the absorbed iron was found to aggregate around the zymogen granules.

In order to investigate the range of absorption in *Ligia exotica*, I first fed the animals with powdered carmine, and at varying intervals, ranging from 2–38 hours, dissected the alimentary canal, fixed and sectioned it. I found that carmine could be detected only in the lumen of the gut and nowhere else in the digestive tract, the particles being ejected through the anus. Patrick tried this method to test the excretory rôle of hepato-pancreas and she came to the conclusion that the glands did not serve an excretory function, a conclusion with which I agree.

On feeding the animals with olive oil stained red with Sudan iii, it was found on dissection and examination of fresh tissues under the microscope, that the whole of the intestinal epithelium and the hepato-pancreas were coloured red with the absorbed oil-globules.

Yonge's method was also employed, but was only partially successful as the colloidal iron in that nutritive form was not available. However, it was seen by this method also that the cells of the hepato-pancreas and the intestinal epithelium have powers of absorption.

The phenomenon of absorption was corroborated by feeding the animals on medicinal Methylene blue and Neutral red. It is a well known fact that certain dyes like Methylene blue and Neutral red stain tissues in their vital condition, and if these are absorbed by the intestinal epithelium and hepato-pancreas, the absorbing cells will indicate the presence of granules of these vital dyes. In order to study, therefore, the physiology of absorption, specimens of *Ligia* were fed on bread, soaked in dilute solutions of medicinal Methylene blue overnight. When these animals were dissected out, it was found that the intestine was stained blue throughout its length; they were, therefore, kept in Ringer's solution and examined under the microscope.

The syncytium of the intestine was stained pale blue, while the nucleus was deep blue and the nucleolus had taken an intense shade of blue. But the most significant point is that granules of Methylene blue could be detected in the cytoplasm around the nuclei, which no doubt demonstrates that the intestinal epithelium is absorptive.

The hepato-pancreas afforded interesting results with regard to the absorption of this vital dye. The lumen of each gland contained granules stained greenish yellow. The wedge-shaped cells of the smallest size were filled with purple grains all round the nuclei recalling very clearly the characteristic stain for mucus in corrosive sublimate preparations, but no fat-globules were found in them, while other cells of the same category but slightly

bigger were found to contain a good number of fat-globules but the purple grains were scanty. Finally, the tall columnar cells were entirely filled with fat droplets but no Methylene blue grains.

Neutral red had been employed by Covell (5, 1928) to study the pancreatic secretion of the guinea-pig in the living state. A similar attempt was made by me in *Ligia*, but these animals are too fragile to withstand long experimental studies. Animals were fed on Neutral red (1% solution) for an hour and were then dissected alive, keeping the hepato-pancreatic tubules in Ringer's solution. The distribution of absorbed Neutral red granules was noted under the microscope.

It was observed that both kinds of cells were absorptive; but the degree of absorption varied. The smaller cells were filled with Neutral red granules all around the nuclei but there were few or no fat-globules, but in some of the other cells both fat and Neutral red granules were found together. In the columnar cells only fat-globules were seen, recalling the results of experiments with Methylene blue.

To corroborate these observations, the glands and the gut of animals fed on Neutral red were fixed in Turchin's fluid, so that the absorbed dye could be preserved and fixed. In sections it was found that the cytoplasm of the hepato-pancreatic cells was stained pale pink towards the inner cuticular border. Certain vacuoles containing Neutral red granules were found between this border and the nucleus, thus confirming the phenomenon of absorption.

5. THE SECRETORY FUNCTION OF THE HEPATO-PANCREAS.

The trend of modern cytology in glandular secretion is directed towards the Golgi apparatus. Interesting and far-reaching results have been obtained on various glandular tissues by Nassanov, Bowen, Brambell, Gatenby, Ludford and Cramer. According to Bowen it has been clearly established that an intimate topographical relationship exists between the Golgi material and the secretory products.

In order to investigate the activity of the cells in the manufacture of secretory products, glands were fixed in Nassanov's and Weigel's modification of Mann Kopsch for Golgi bodies, mitochondria, secretory granules and the nuclear apparatus. Both these osmic preparations give identical results and Golgi apparatus was found to hold a close relationship with the secretory vacuoles of fat, indicating probably that the latter arise in relation to the Golgi bodies. But the exact details of synthetic operation have still to be investigated.

The origin of zymogen granules is still problematical. Nassanov's and Da Fano's preparations have shown that they are found in topographical relationship with Golgi bodies in the

wedge-shaped cells, but this conclusion is only tentative and needs further critical evidence.

The secretion of the hepato-pancreas in Isopods is essentially lipoidal in nature and presents certain characteristic features. We have noted that the columnar cells are the mature phase of cellular growth and that it is these that are concerned with the discharge of secretory products. These cells are cut off from their basal portions either without the nuclei or with the nuclei, in which case they are intact and fall into the lumen carrying the secretory products of fat, enzymes produced by the zymogen granules, and the distintegrated Golgi material (fig. 6). These products are then pumped into the intestine by the rhythmic contractions of the glands where they react on the liquid food absorbed. This statement is substantiated by the presence of discharged cells in the intestinal tract. The fate of these fat-globules is little understood at present. In this connection we come to the much disputed question of the types of cell and cell-differentiation in the Isopod hepato-pancreas. Webber is of opinion that the long columnar cells are morphologically and physiologically different from the smaller wedge-shaped cells. Later workers like Frenzel, Murlin, and Nicholls hold that their apparent differences are due to their different stages of growth. Patrick, on the other hand, identifies the long columnar cells as 'fat-secretory and storage cells', and the wedge-shaped cells as purely 'mucous cells', a statement which has been proved to be untenable.

Microscopical examination of the glands-cells alone cannot give a conclusive proof for one or the other view, for cells are not physico-chemical entities alone, but are, above all, biological and physiological. Therefore, I attempted to examine the cells under experimental conditions of absorption of Methylene blue and Neutral red. It has already been pointed out that the smaller cells are indicative of great absorption, the larger ones of little or none, while the intermediate ones are partly absorptive and partly secretory. I, therefore, come to the conclusion that the cells of the hepato-pancreas show progressive stages of growth and differentiation, the smaller cells being at first enzymatic and mucus-secreting with a great power of absorption, and that later they become fat-secreting and storing. I hope that a critical study of the Golgi apparatus in these cells will clear our doubts about the morphological differentiation and the physiological rôle of these cells and this point has to await further work.

6. Summary.

I. The intestinal epithelium and the hepato-pancreas of the two Isopods, *Ligia exotica* and *Armadillio elevatus*, are both absorptive.

II. The differences in the cells of the hepato-pancreas are due to their different stages of growth. The smaller cells are primarily enzymatic and mucus-secreting to begin with, but later develop into columnar cells which are predominantly fat-secreting and storing.

III. The fat globules are secreted in vacuoles found in relation with the Golgi material, the latter being, therefore, concerned with fat-secretion in the cells.

IV. The secretion of the glands is typically lipoidal in character, the nuclei remaining intact in the cells, which are discharged '*in toto*' into the lumen of the gut.

V. Zymogen granules have been found to arise in relation with the Golgi apparatus in the wedge-shaped cells and they indicate that these cells are physiologically more active in absorption and intra-cellular digestion.

7. Acknowledgments.

It gives me great pleasure to express my sincere thanks to Professor R. Gopala Aiyer, Director of the Zoological Laboratory, University of Madras, for his interest and help during the short period of my work, and to Professor K. N. Bahl of the Lucknow University for his suggestive and critical revision of my paper.

Also I wish to express my deep gratitude to my Alma Mater, The Women's Christian College, Madras, for granting me the post-graduate scholarship to carry out this work.

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Some Recent Advances in Insect Embryology, with a Complete Bibliography of the Subject.

By MITHAN LAL ROONWAL.

(*Communicated by Dr. B. Prashad.*)

CONTENTS.

I. INTRODUCTION.

After a lull during the second decade of the twentieth century, interest in insect embryology is to-day showing signs of revival. This is to be welcomed as, notwithstanding the enormous amount of work done on this subject—nearly 700 references have been listed at the end of this account—, certain outstanding problems are still productive of much divergence of opinion. The process of gastrulation, the origin of the mid-gut epithelium and, in short, the general problem as to how far the classical germ layer theory is applicable to insects, are matters of dispute to-day. Recent work has provided satisfactory solutions for at least some of these problems. Moreover, the discovery of the labral and preantennary pairs of coelomic cavities by WIESMANN (1926) in *Carausius*, and the confirmation of the former by MELLANBY (1936) in *Rhodinus* and by ROONWAL (1937) in *Locusta*[1] has lent a new interest to the problem of head segmentation among Arthropods in general and insects in particular. These and other discoveries have tended to support, on very strong embryological evidence, the 7-segmental nature of the insect head and this view is, therefore, presented in the following account. A new interpretation of the insectan protocerebrum in support of the same view is also given. Advance in our knowledge has been made in several other fields also, such as those relating to the abdominal appendages, the embryonic membranes, the provisional dorsal closures, the embryonic blood sinuses, etc., and all these structures are dealt with briefly.

Owing partly no doubt to the large amount of yolk in the insect egg, its early embryological development has become extremely distorted and, therefore, difficult of interpretation, especially in matters relating to the formation of the germ layers. At the same time it cannot be emphasized too strongly that the first essential for a correct approach to the solution of the various controversial points is to employ the very highest standard in the technique both of the handling of material and of actual observation. Given the former, the one requisite most needed is a complete freedom from theoretical prejudices. A perusal of the original papers indicate that not a few embryologists have failed in this quality. Regarding the technique of the handling of material, two requirements are essential. These are: (1) Good fixation and proper sectioning. For example, an artificial space in mesodermal tissues, caused by bad fixation, might easily, but wrongly, be interpreted as a coelomic cavity. (2) Accurate timing of the embryonic stages. Eggs, from the moment of laying, must be incubated at constant temperature and humidity, and examined at regular and short intervals of

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[1] Also in *Pteronarcys* by MILLER (1939), see Appendix, p. 105.

time. While this procedure ensures accurately timed stages, a word of caution is necessary lest the embryologist should rely solely on this method. It has been found (WIESMANN, 1926; SLIFER, 1932, *b*) that even under a uniform external environment, the rate of development in the same egg-batch may vary from egg to egg within fairly wide limits. As pointed out by WIESMANN, such characters as the number of segments differentiated, the first appearance of the proctodæum (and the stomodæum), the beginning of the differentiation of the fat body, etc., provide supplementary and often more accurate criteria than a temperature-time scale for determining the developmental stage of the embryo. Even so it is not always possible to draw a sharp line between one developmental period and another. In short, the embryologist must be certain that he has missed no developmental stage, however insignificant and unworthy of record it might seem to him from his previous theoretical knowledge. Failure to satisfy this requirement—because the older embryologists incubated their eggs either in the room or in the open, where environmental conditions fluctuate considerably—was often the cause of overlooking several fleeting but nevertheless important phenomena, as, for example, the supernumerary ventral (gastral) grooves which are probably of a much more general occurrence among insects than has hitherto been admitted. Thus, in *Locusta* two ventral grooves are formed of which the first one lasts for less than 4 hours (at 33°C.), and the second one, which appears a few hours later, also lasts for an equally short period. On the other hand, the fulfilment of the above requirements in several recent papers has produced results of considerable value.

Finally, it is a pleasure to acknowledge my indebtedness to DR. BAINI PRASHAD, Director, Zoological Survey of India, for his kindness in critically going through the manuscript and suggesting many improvements, and for correcting the proofs.

II. HISTORICAL.

ARISTOTLE, in the last three-quarters of the fourth century B.C., had noted that some insect eggs have 'soft shells' and increase in size after being laid. Such eggs he termed as 'imperfect' in contradistinction to 'hard-shelled eggs', such as those of birds, which do not so increase in size. He, however, regarded the chrysalis also as an egg stage. The increase in size of insect eggs was re-discovered several centuries later by RATHKE (1844) in the eggs of the mole-cricket, *Gryllotalpa vulgaris*, and some of the caddis flies or Trichoptera (*vide* ROONWAL, 1936, *a*)[1]. FABRICIUS (1687) 'marks a definite

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[1] It is of interest to note in this connection that SLIFER (1938, *a*) has recently discovered in the egg-membrane of the grasshopper,

advance upon ARISTOTLE when he says that silk worms and other insects are born into their larval state from an egg, though he still terms the chrysalis an egg, and therefore holds that they are generated twice' (N., pp. 87–89). HARVEY, in the first half of the seventeenth century, believed in *Omne vivum ex ovo* [1], implying that even the most imperfect and lowest animals are born from eggs and not by spontaneous generation. He writes, 'We shall show that many Animals themselves, especially insects, do germinate and spring from seeds and principles not to be discerned even by the eye, by reason of their contract, invisible dimensions . . .' (N., p. 122). Unfortunately, his further notes on the generation of insects were destroyed in his house in London at the time of the Civil War. HARVEY, like ARISTOTLE, was an ardent epigenticist. The final death blow to the idea of spontaneous generation was given by REDI (1688) whose work must consequently remain, although indirectly, the starting point of developmental studies on all minute oviparous invertebrates. MALPIGHI (1669), the 'principal glory' of the 'micro-iconographic' school, and SWAMMERDAM (1737) were largely concerned with the larval and adult anatomy of the silk-worm, honey-bee and other insects, and their few observations on insect eggs are not of much importance from the purely embryological point of view [2]; both these authors were preformationists. LEEWENHOEK (1695) made some interesting observations on the eggs of fleas.[3]

After this there is a long gap of over a century during which no observations were made on insect embryology. However, for comparative animal embryology as a whole, it was a most important period, for during it the germ layer theory was slowly taking shape. In the formulation of this theory, there stand

Melanoplus differentialis, a special water-absorbing area which she calls the 'hydropyle'.' This area is located in the 'yellow cuticle' at the posterior or micropylar end of the egg. The egg absorbs water from outside largely through the hydropyle.

[1] This pithy saying itself is, however, not attributable to HARVEY. Nor is it strictly correct in the light of later advances in our knowledge. The Protista, for example, do not produce eggs.

[2] SWAMMERDAM, however, rendered great service by observing and figuring the eggs of a large number of insects, including the body-louce, dragonflies, mayflies, honey-bee, humble-bee, ants, and several beetles and moths. In the middle of the developing egg ('nit') of the louce he observed a small area showing heart-like pulsations; this he called the 'pancreas' as 'it moves up and down with the stomach'—presumably he was observing either the bulbus arteriosus or the peristalsis of the lateral body-walls in the late embryo.

[3] The substance of this paragraph, giving the early history of insect embryology, is largely taken from Dr. J. NEEDHAM's excellent book *A History of Embryology* (1934), and the quotations taken therefrom are acknowledged with the suffix N., followed by the page of the book. For references to the embryological works of ARISTOTLE, FABRICIUS and HARVEY, the same book should be consulted.

out prominently the works of WOLFF (1759) and PANDER (1817), culminating in the classic book of VON BAER (1828).

The first clear reference to early insect embryos was probably that by SUCKOW (1818) who observed that in the eggs of *Bombyx* (*Gastrophaga*) *pini* (Lepidoptera) a small dark spot is formed in the centre of the originally clear yolk. This he rightly regarded as the early embryo (germ disc), but, as BURMEISTER (1832) later pointed out, the embryo or ventral plate lies on the surface of the yolk, not in the centre. SUCKOW also observed the serosa, the alimentary canal, the tracheæ, the dorsal vessel, the central nervous system and finally, the gonads in the late embryo. The next contribution was that of RATHKE (1832), contained in a small paper of eight pages exclusively devoted to the embryology of the cockroach, *Blatta orientalis*. He examined embryos dissected out of the egg, but did not cut sections. This was soon followed by the works of KÖLLIKER (1842) and RATHKE (1844).

The intensity of the active period which followed[1] was heightened by the invention of the microtome in about 1860 and, with it, the rapid development of the section-cutting technique. Authors who made special contributions during this period are mentioned below; in their earlier works they did not study sections, but later they employed that technique:—WEISMANN (1863–1882), METSCHNIKOFF (1865–1875), BALBIANI (1866–1885), DOHRN (1866–1876), GANIN (1869–1874), BRANDT (1869–1880), and others. KOWALEWSKY (1871–1886) first studied insect embryology by cutting sections and thus laid the foundation of much of our knowledge of the subject as understood to-day, and it was BOBRETZKY (1878) who first followed the process of cleavage in large yolk-laden eggs with the help of sections. All these authors dealt with pterygotan insects. It was, however, during the last decade of the nineteenth century and the first decade of the twentieth that activity was most intense and the greatest amount of work on insect embryology was done. No doubt, this was due partly to the development of a tolerably satisfactory technique of section-cutting and staining, for insect eggs, like all others eggs which are rich in yolk, are notoriously difficult to section. It is impossible to mention all the authors in this review, and only a few whose contribution has been the greatest will be referred to. Two of the greatest masters of insect embryology, *viz.*, GRABER (1877–1891) and HEYMONS (1890–1912), deserve first mention. The brilliant and remarkably penetrating studies of GRABER dealt with an extensive series of pterygotes, including the Orthoptera, Odonata, Hemiptera, Trichoptera, Lepidoptera, Coleoptera,

[1] For a detailed review of this period up to 1897, consult LÉCAILLON (1898, *a*).

Hymenoptera, Diptera and others. To the insect embryologist, his original papers are indispensable even to this day. Next comes HEYMONS whose classical studies of the Orthoptera and Dermaptera, as well as his views on bi-phased gastrulation and the absence of a functional insectan endoderm, are well known. He also studied the Ephemeroptera, Odonata, Hemiptera and Thysanura (*Lepisma*), and his great work on *Scolopendra* (Chilopoda) may also be mentioned. Reference may now be made to some other important works, such as those of NUSBAUM (1882–1891); WILL (1883–1888) who first suggested the 'newer bi-phased gastrulation theory' for insects; CHOLODKOWSKY (1888–1895); BLOCHMANN (1884–1895); HEIDER (1885–1897); HENKING (1888–1892); WHEELER (1889–1893); LÉCAILLON (1897–1898); and CARRIÈRE and BÜRGER (1897). The work of the last-named authors on the mason-bee, *Chalicodoma muraria*, is perhaps the most complete embryological account in existence of a single insect. Workers on the Apterygota, such as CLAYPOLE (1892; 1898), UZEL (1897–1898) and PHILIPTSCHENKO (1912), must also be mentioned, as well as those on the parasitic Hymenoptera, *viz.*, MARCHAL (1897–1906) and SILVESTRI (1906–1921). In this period also appeared the well-known work of KORSCHELT and HEIDER (1892–1910) on invertebrate embryology.

Coming to a more recent period, we have the works of HIRSCHLER (1906–1924) whose chapter on 'Embryogenese der Insekten' (1924) in Schröder's 'Handbuch der Entomologie' is undoubtedly the most comprehensive general account of insect embryology that has appeared in recent times. The second decade of the twentieth century did not prove very productive, partly owing no doubt to the intervention of the Great World War. The works of NELSON (1911–1918) on the honey-bee are, however, a notable exception. But in more recent times, interest in insect embryology has revived and we are having a large number of papers on the subject. Among them may be especially mentioned the works of GRANDORI (1911–1932) on *Bombyx mori*, coccids, etc.; BLEDOWSKI and KRAINSKA (1926) on the parasitic Hymenopteran, *Banchus femoralis*; the elaborate work of WIESMANN (1926) on coelom formation in the stick insect, *Carausius morosus*, Br. (Orthoptera); EASTHAM (1927–1930) on *Pieris rapae* (Lepidoptera); NOSKIEWICZ and POLUSZYNSKI (1928) on the parasitic genus *Stylops* (Strepsiptera); ROONWAL (1935–1939) on the African Migratory Locust, *Locusta migratoria migratorioides* R. & F. (Orthoptera), and on gastrulation in general; MELLANBY (1935, 1936) on *Rhodinus* (Hemiptera); SCHLÖZEL (1937) on some Anoplura (including Mallophaga); and finally, TIEGS and MURRAY (1938) on *Calandra oryzae* (Coleoptera). (Also see Appendix, p. 105.)

III. SOME RECENT ADVANCES.

1. Technique.

The sectioning of the yolky eggs of insects has always been a difficult and laborious process, but the technique recently evolved by Slifer and King (1933) and modified by Roonwal (1935, *a*) has made this task easy. Fixed eggs are cut into two transverse halves and soaked for 24 hours in a 1–4% solution of carbolic acid in 80% alcohol. They are then dehydrated in 95% alcohol, cleared in carbol-xylol and embedded, as usual, in wax (M.P. 52°C.) for 10–30 minutes according to the size of the egg. The wax block is then trimmed so as to *expose* the *cut* side of the egg and then soaked in water for 24 hours. The block then cuts very easily. The duration of soaking in carbolic acid solution, as well as in water, can be shortened to about 6 hours in a vacuum bath. A 4% carbolic acid solution is not always safe to use and a weaker strength is often preferable.

2. Gastrulation and the Germ Layers [1].

(*a*) *Theories of Gastrulation.*

(i) *The older theories.*

Until recently, two main views existed in regard to the nature of gastrulation and the formation of the germ layers in insects. These are:—

1. A true blastula is present in insects and is formed when the cleavage cells reach the egg-periphery. Gastrulation occurs afterwards when the inner layer is differentiated. Yolk cells have no germ layer value. Endoderm is usually bipolar in origin. This view was advanced by Kowalewsky (1886) and supported by Wheeler, Nusbaum and Fulinsky, Strindberg, and more recently by Eastham (1927; 1930, *a*, *b*), Thomas (1936) and others.

2. No blastula occurs, the so-called blastula of the first view being regarded as the first gastrulation stage. Gastrulation occurs in two stages. The interpretations of this view fall into two groups, thus:

(*a*) Older bi-phased gastrulation theory.—The first gastrulation phase is represented by the separation of the primary yolk cells from the other cleavage cells, and the second phase by the immigration of secondary yolk cells from the primary epithelium.

[1] For a review of the older literature on germ layer formation in insects, see Eastham (1930, *a*).

Differentiation of inner layer is not a gastrulation act. Yolk cells alone represent endoderm, but, since they degenerate, no endoderm shares in the formation of adult body. Insectan mid-gut is ectodermal in origin. This theory was first clearly put forward by HEYMONS (1895, *a*; 1901), and supported by LÉCAILLON (1897–1898), SCHWARTZE (1899) and others.

(*b*) Newer bi-phased gastrulation theory.—The first phase corresponds to the first phase of the older theory, but the second phase is represented by centripetal separation of yolk cells as well as by differentiation of inner layer. Primary epithelium is regarded as ectoderm, not blastoderm. Mid-gut epithelium is endodermal. This theory was first put forward by WILL (1888), but we owe its full exposition to HIRSCHLER (1912 ; 1924).

(ii) *The new theory of multi-phased gastrulation.*

This was suggested by ROONWAL (1936, *b*) in order to explain several embryological facts which were previously not explicable on the bi-phased gastrulation theories. Four phases were tentatively recognized in *Locusta*. More recently, the theory has been amplified (ROONWAL, 1939, *b*) and has been shown to be applicable not only to most insects but also to several other Arthropods. The essential features of the amplified theory are: (i) Blastula stage is suppressed in most cases. (ii) Gastrulation has undergone both temporal and spatial elongation, and become multiphased. It generally occurs in three phases and numerous sub-phases of the first and second order. (iii) All the three germ layers have acquired a quadruple nature. We may distinguish in them firstly, primary and secondary portions. Secondly, each of these may contain permanent and evanescent portions. (iv) The primary germ layers tend to undergo various degrees of reduction and may even be totally suppressed. (v) Multi-phased gastrulation is brought about by a combination of the various modes by which uni-phased gastrulation generally occurs. (vi) The definitive mid-gut epithelium is generally a secondary formation belonging to the secondary endoderm. (vii) Yolk cells are endodermal in nature.

Recently, TIEGS and MURRAY (1938) have shown that the mid-gut epithelium in *Calandra oryzæ* arises from the blind ends of the stomodæal and proctodæal invaginations. While this is only one more confirmation of what has been previously demonstrated by several authors in a variety of insects, it is the interpretation of this fact by TIEGS and MURRAY that calls for some remarks. They maintain that endoderm does not occur in the embryo of *Calandra*, and further generalize that 'when the gastral epithelium arises early, then endoderm forms; but when

it does not appear till much later, there is no endoderm'. One would naturally ask: What then is the validity of the well-established germ layer theory if endoderm may be altogether absent in an embryo? The answer to this question would seem to lie in the multi-phased gastrulation theory in its amplified form.

(*b*) *Some Structures connected with Gastrulation.*

Recently, some new and important structures have come to light in connection with insect gastrulation. At the same time, some of the older structures have either received new interpretations or been given new names in accordance with modern ideas on gastrulation. They are mentioned below.

Supernumerary ventral grooves.—One mid-ventral groove analogous, but not homologous, with the blastopore, is generally characteristic of embolic gastrulation. Recently it has become evident in insects that besides the main groove from the roof of which the inner layer is proliferated, other grooves are also formed, although these latter do not take an important share in the formation of the inner layer. Nevertheless, the supernumerary grooves constitute a strong support for the multi-phased gastrulation theory. In accordance with the time of their appearance, the grooves have been named by ROONWAL (1936, *b*) as the first, second and third ventral grooves, of which the second one is the main groove occurring in all embolic insects. The first ventral groove has been recorded in *Pieris* (EASTHAM, 1927), *Calandra* (INKMANN, 1933), *Locusta* (ROONWAL 1936, *b*) and *Carausius* (THOMAS, 1936). The third ventral groove was recorded by KOROTNEFF (1885) in *Gryllotalpa*, but its significance was not appreciated, since neither the first nor the second groove occurs in this insect.

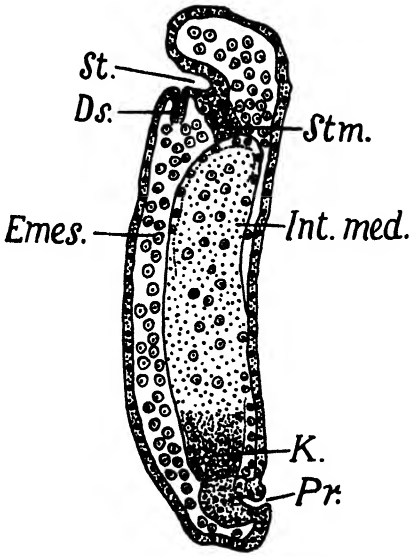
Primary epithelium.—This name has recently been given to the first cell-layer formed in insect eggs (ROONWAL, 1936, *b*). It is the so-called blastoderm of the older authors and the 'Oberflächenepithel' of HIRSCHLER (1924). It represents the ectoderm.

End-ectodermal masses.—The cell proliferations developing in many insects at the blind ends of the stomodæum and the proctodæum and forming the mid-gut epithelium, have been variously interpreted as purely ectodermal or purely endodermal. Since in ontogenic origin they are undoubtedly ectodermal and in phylogeny endodermal, they have been termed as 'end-ectodermal masses' (ROONWAL, 1939, *b*). They represent a portion of the secondary endoderm.

3. THE ALIMENTARY CANAL AND THE MALPIGHIAN TUBULES.

The true nature of the insectan mid-gut epithelium has been stated above, and I shall briefly describe here some new and recent conclusions regarding its actual mode of origin in

ontogeny. The share of the yolk cells in the formation of the mid-gut epithelium had been formerly shown only in two cases, *viz.*, in *Lepisma* (HEYMONS, 1897, *a*) and the Libellulidæ (TSCHUPROFF, 1903). In both instances the accuracy of the observations has been doubted by other workers. It is, therefore, of considerable interest that more recent authors have found this condition in some other insects where the mid-gut epithelium is of a mixed origin. In *Bombyx mori* (GRANDORI, 1932, *a*) the mid-gut epithelium is claimed to arise from the ectoderm and *yolk cells*. In the Ichneumon, *Banchus femoralis*, BLEDOWSKI and KRAINSKA (1926) distinguish three sections of the mid-gut, *viz.*, a middle *yolk sac* which forms the main portion of the mid-gut epithelium and, at either ends of the sac, a small 'stomodæal' and a small 'proctodæal' mid-gut (Text-fig. 1).



Text-fig. 1. Longitudinal section of the embryo of *Banchus femoralis*, showing the triple origin of the mid-gut epithelium. Semi-diagrammatic. (*Adapted from* BLEDOWSKI and KRAINSKA, 1926.)

Ds., ductus sericterii; *Emes.*, inner (lower) layer; *Int. med.*, mid-gut of yolk-sac origin; *K.*, posterior cell-cap (rudiment of 'proctodaeal' mid-gut); *Pr.*, proctodæum; *St.*, stomodæum; *Stm.*, anterior cell-cap (rudiment of 'stomodaeal' mid-gut).

The majority of the recent investigations point to an embryonic origin for the regeneration cells and nuclei of the mid-gut epithelium. BUSHNELL (1936) has made the interesting discovery that in the beetle *Acanthoscelides* the mid-intestinal epithelial cells of the late embryo are of two sizes. The larger ones form the functional larval epithelium, while the smaller ones become the

regeneration cells. The nuclei of the larger cells have nearly twice the volume and contain twice as many prochromosomes as those of the smaller ones—the volume and prochromosome number respectively being 195 cu. μ. and 40 in the former and 113 cu. μ. and 20 in the latter. This author further suggests that the nuclei of the regeneration cells may have a two-fold origin: firstly, from certain small cells which become isolated at the base of the mid-gut epithelium during early larval development; and secondly, from 'pseudo-reduction' divisions of the large nuclei in the larval epithelium.

Sometime ago, HENSON (1932) attempted to homologize the stomodæal and proctodæal invaginations of *Pieris* embryo with the oral and anal remnants of the blastopore of *Peripatus*. This ingenious view, along with HENSON's idea of the endodermal nature of the Malpighian tubules, is apparently not correct and has not received acceptance by other authors.

4. THE INVERSION OF CELL POLARITY IN THE EARLY GERM BAND (Text-fig. 2).

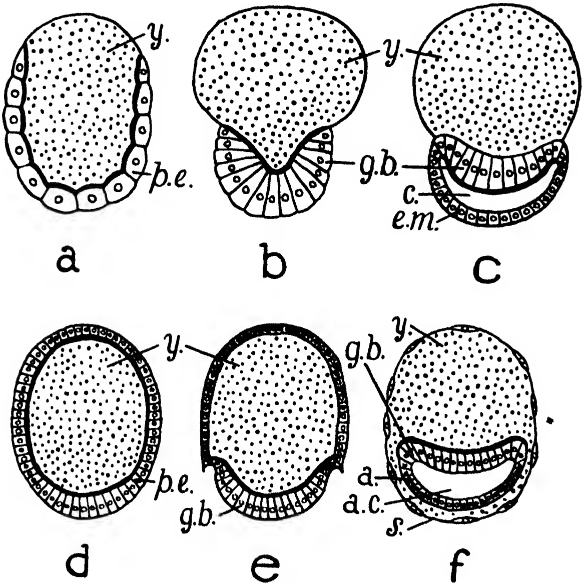
In 1903 BRUES described a peculiar condition in the Strepsipteran *Xenos peckii* where the yolk, instead of lying inside the vesicle formed by the primary epithelium comes to lie *outside* it. This condition was confirmed by HOFFMANN (1914) in *Xenos bohlsi*, and some years later by NOSKIEWICZ and POLUSZYNSKI (1928) in their careful work on *Stylops*. The latter authors further explained this condition by suggesting that there occurs, in the region of the germ band of the Strepsiptera, an inversion of cell polarity. As a result of the inversion, the inner or normally dorsal side of the cells, abutting in the beginning against the yolk, comes to point away from the latter and thus determines the ventral side of the future embryo. The outer ends of the cells, on the other hand, point towards the yolk and determine the dorsal side. In all other groups of insects, the inner walls of the cells determine the dorsal side of the future embryo, and the outer walls the ventral side.

5. THE SEGMENTATION OF THE HEAD (Text-fig. 3).

(a) *Introductory.*

The number of metameric segments composing the insect head has been variously estimated as from four to nine. An enumeration of all these views need not be made as they have been discussed recently by several authors, notably by WIESMANN (1926), EASTHAM (1930, *b*), IMMS (1937), SNODGRASS (1938) and WEBER (1938). It may, however, be mentioned that the number of segments most commonly regarded as entering into the head is either six or seven. The existence of the last five segments, *viz.*, the antennary, the mandibular, the intercalary or

premandibular, the first maxillary and the second maxillary or labial, has been accepted by nearly all authors. HANSEN [1]



Text-fig. 2 (*a*)–(*f*). Diagrams showing the inversion of cell polarity in the early germ bands of the Strepsiptera. *Upper row* (*a*)–(*c*)—*Xenos bohlsi* (HOFFMANN, 1914); *lower row* (*d*)–(*f*)—pterygote insect, other than the Strepsiptera, and in which both the amnion and the serosa are formed. The primary inner ends of the cells are shown in heavy line; the yolk is dotted. (*a*) and (*d*)—Early or primary epithelium stage. (*b*) and (*e*)—Later stage. In (*b*) the primary epithelium has shrunk, and the yolk is being extruded. In (*e*) the amniotic folds are being formed. (*c*) and (*f*)—Still later stage. In (*c*) the single embryonic membrane (=amnion plus serosa) is formed and the yolk is completely extruded. Note the inversion of cell polarity in the germ band, when compared to (*f*). In (*f*) both the amnion and the serosa have been formed. (*After* NOSKIEWICZ and POLUSZYNSKI, 1928.)

a., amnion; *a.c.*, amniotic cavity; *c.*, cavity between germ band and rudiment of embryonic membrane; *e.m.*, rudiment of embryonic membrane (amnion plus serosa); *g.b.*, germ band; *p.e.*, primary epithelium; *s.*, serosa; *y.*, yolk.

(1893 and 1930) has claimed, on morphological grounds, the existence of a maxillular segment, as evidenced by the presence of a pair of reduced but true appendages, between the mandibles and the first maxillæ. The claim is supported by HENRIKSEN (1928). Recent work on apterygote embryology (SILVESTRI,

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[1] HANSEN, H. J., 1893.—*Zool. Anz.*, vol. XVI, pp. 193–198 and 201–212.

——— 1930.—Studies on Arthropoda. III.—Copenhagen.

1932), however, does not support this view, and the existing evidence for it must be regarded as inconclusive. The present discussion will, therefore, be confined to the segments lying in front of the antennary one. One or two of such segments have been variously claimed to exist, according as the total number of head segments is regarded as either six or seven, and have been known under a diversity of names, some of which are given below: (1) Head lobes segment or primitive head segment or protocephalic segment; its ganglionic constitution is homologous with the prostomial archicerebrum of the Annelida. (2) Ocellar segment. (3) Ocular segment. (4) Oral segment. (5) Acronic and preantennary segments. (6) Labral and encephalonic (brain) segments. Among the more important recent views concerning the segments lying *in front of the antennary one*, the following may be mentioned:—

WIESMANN (1926).—Two segments, the labral and the preantennary, exist. Acron is rudimentary and probably of no segmental importance. The head is regarded as 7-segmental.

EASTHAM (1930, *b*).—One segment, the labral, exists, and the protocerebrum is its ganglion. The preantennary segment is denied. The head is regarded as 6-segmental.

IMMS (1937).—Only one segment exists. The labrum does not represent a true segment. The first true segment is the preantennary or ocular. The head is regarded as 6-segmental.

HOLMGREN [1] (1916) and HANSTRÖM [2] (1927–1930).—The separation between the protocerebrum and deutocerebrum in insects and other Arthropoda is secondary, the two structures together being equivalent to the annelidan archicerebrum. The tritocerebrum is the neuromere of the first true segment, with the antennæ as its appendages. The labrum and the preantennary appendages belong to the category of prostomial tentacles of Annelids and are not true appendages. Behind the first or 'tritocerebral' segment come the three gnathal segments, the mandibular, maxillary and labial. The intercalary segment is denied. The head is regarded as 4-segmental. This view, which has been specially elaborated by HANSTRÖM, is accepted by SNODGRASS (1935), but has not gained wider support. It almost

[1] HOLMGREN, N., 1916.—*Kungl. Svenska Vetensk. Akad. Handl.*, vol. LVI, No. 1, pp. 1–303.

[2] HANSTRÖM, B., 1927.—*Zeit. f. Morph. Ökol. Tiere*, vol. VII, pp. 543–596.

——— 1928(*a*).—Vergleichende Anatomie des Nervensystems der wirbellosen Tiere unter Berücksichtigung seiner Funktion.—Berlin.

——— 1928(*b*).—*Zeit. f. Morph. Ökol. Tiere*, vol. XI, pp. 151–160.

——— 1929.—*Ibid.*, vol. XIII, pp. 329–358.

——— 1930.—*Ibid.*, vol. XIX, pp. 732–773.

completely disregards the evidence from embryology, such as the presence of appendages, cœlom sacs and neuromeres, and is for that reason unsound.

In a recent paper, SNODGRASS (1938) contends (p. 94) that 'a radial structure secondarily affects the anterior end of the articulate trunk because of the subapical position of the mouth'. Consequently, he argues, the cephalic cœlom sacs, being radial in position, cannot represent somites in the manner of paired sacs lying post-orally. The strong objection to this view is that cœlom sacs cannot lose their former segmental significance merely by virtue of their secondarily acquiring a radial position. In the same paper SNODGRASS suggests a new definition of the acron so as to represent by that term 'a primarily unsegmented archicephalon corresponding with the annelid prostomium' (p. 94). Such an acron, he contends, is represented in the arthropod embryo by the cephalic lobe (or lobes) bearing the eyes, the labrum, the preantennæ and the first antennæ. It is difficult to accept this new definition until much stronger evidence than is hitherto available is forthcoming in favour of it. In the mean time it is desirable to retain the older definition of the acron as the unpaired apical portion of the arthropod head lying in front of the first true somite; such an acron is seen, among others, in *Scolopendra* (HEYMONS, 1901) and in *Carausius* (WIESMANN, 1926).

Before proceeding further, it needs to be pointed out that in appraising the segmental composition of the head, whilst evidence from morphology is obviously necessary, embryological evidence is still more important, as has been admitted by all but a few writers on the subject. In regard to the evidence from embryology, three criteria have been universally accepted as establishing the existence of a somite. These are the presence of (1) a pair of appendages; (2) a pair of cœlomic cavities; and (3) a neuromere, *i.e.*, a pair of nerve ganglia homodynamous with the ganglia of the ventral nerve chain. Consequently, the recent discovery of a pair of preantennary appendages and of labral and preantennary cœlom sacs in some insects is of special interest. Its significance is discussed below, and, at the same time, a new interpretation of the segmental composition of the insectan protocerebrum is presented. Evidence from these sources, it may be added, points to a 7-segmental nature of the insectan head.

(*b*) *A New Interpretation of the Composition of the Insectan Protocerebrum.*

(i) *General.*

The insectan brain has hitherto been generally conceded as being composed of three primary portions, *viz.*, the proto-, deuto- and tritocerebrum, corresponding to the first (labral,

preantennary, oral, ocular, etc.), second (antennary) and third (intercalary) cephalic segments. The view of HOLMGREN and of HANSTRÖM mentioned above, *viz.*, that the proto- and deutocerebrum together form a single ganglionic unit equivalent to the prostomial archicerebrum of the Annelida, is unacceptable. The existence of the deutocerebrum as belonging to the antennary segment is well established on sound embryological grounds, and this as well as other cognate pieces of evidence are completely disregarded by these authors.

In the following account the deuto- and tritocerebrum are regarded, as heretofore, as discrete brain segments belonging to the antennary and intercalary somites respectively. With regard to the composition of the protocerebrum, however, a new interpretation is presented.

(ii) *The development of the protocerebrum.*

Each of the components of the brain, *viz.*, the proto-, deuto- and tritocerebrum has been generally shown as developing from the ventral ectoderm in exactly the same manner as the other ganglia of the ventral nerve chain, and, therefore, as being homodynamous with the latter. While opinion is agreed that this is so in the case of the deuto- and tritocerebrum, the protocerebrum has long been regarded as developing in a more complicated manner and, therefore, possibly not being strictly homodynamous with the other two portions.

The embryological development of the protocerebrum has been best studied in the Orthoptera and the Dermaptera—by VIALLANES (1891) in *Mantis*; WHEELER (1893) in *Xiphidium*; HEYMONS (1895, *a*) in *Forficula*; and, more recently, by BADEN (1936) in *Melanoplus* and ROONWAL (1937) in *Locusta*. The observations of these authors agree in essential points and, for the following description, *Locusta* will be taken as an example. The protocerebral rudiments of *Locusta* lie on either side of the labrum and the stomodæal invagination and occupy the entire head lobes. They thus extend over a much more considerable area than either the deuto- or the tritocerebrum. From the very beginning, each half of the protocerebrum is divided into *two* lobes which are separated from each other by means of a hypodermal invagination. A third lobe, the optic lobe, is then differentiated from the lateral ectoderm in a manner different from and independent of the other two protocerebral lobes, but subsequently becomes connected with the latter. It is separated from the middle protocerebral lobe by means of a hypodermal invagination which, like the one between the other two lobes, disappears afterwards. In this manner, three protocerebral lobes are formed which are, following VIALLANES (1891), generally known as the first (optic), second and third lobes, counting from the outside. The number of rows of the primary or mother neuroblast cells is about 4–6 in the third lobe and about 3-4

in the second one. The development and fate of these neuroblasts is similar to those of the deuto- and tritocerebrum and of the ganglia of the ventral nerve chain (Table 1).

In the formation of the optic lobe, neuroblasts do not take part, and the lobe arises from the ectoderm at the dorso-lateral edge of the head lobes in the following manner:—The aforesaid region becomes thickened into a more or less rounded mass in which the peripheral nuclei are arranged in a single row, while in the rest of the mass they do not exhibit any regular arrangement. This mass is the common rudiment of the optic ganglion and the eye-plate. In a slightly older stage, the inner mass (the optic lobe) begins to cleft from the outer layer (the eye-plate), and sometime afterwards this separation is complete. In the mean time, the optic lobe becomes connected with the second protocerebral lobe which ultimately forms the opticon or internal medullary mass of the optic lobe and also the optic nerve. The optic lobe then gradually becomes differentiated into its various elements. During blastokinesis, the optic lobe acquires a connection with the eye-plate for the second time.

(iii) *The segmental significance of the composite nature of the protocerebrum* (Text-fig. 3 and Table 1).

The prevalent view is that the whole of the protocerebrum represents a single ganglionic pair homologous with the prostomial archicerebrum of the Annelida. WHEELER (1893) considered the possibility of the protocerebrum as being composed of more than one neuromere, but rejected it. WIESMANN (1926) remarked that, theoretically, the neuromeres of the labral and preantennary segments could be accepted as lying in the protocerebrum, but no proof was brought forward in support of the suggestion.

In the following discussion I have attempted to prove that the protocerebrum is composed of two neuromeres, the labral and the preantennary.

(α) *The optic lobes.*—The optic lobes (the so-called first protocerebral lobes) among insects develop either by invagination (Hymenoptera and Coleoptera) or by delamination (Orthoptera and Dermaptera). In neither case do neuroblasts share in their formation. A few doubtful cases of neuroblasts occurring in the optic lobes have been reported by VIALLANES (1891) in *Mantis* and by HEYMONS (1895, *a*) in *Forficula*, but, in view of the negative indications of all other authors, these exceptions need adequate confirmation before they can be accepted. If they are found to be correct, the neuroblasts in these instances would probably be regarded as having invaded the optic lobes secondarily. The entire manner, including the absence of neuroblasts, of the origin of the optic lobes in *Locusta* and other insects clearly shows that they are not homodynamous with the other two lobes of the protocerebrum, nor are they

TABLE 1.

The ganglionic composition of the brain of Locusta, *as compared to a ganglion of the ventral nerve chain.*

Organ and its structure.	Brain.					A ganglion of ventral nerve chain.
	Protocerebrum.			Deutocerebrum.	Tritocerebrum.	
	Two pairs of primary lobes (=two pairs of true ganglia).		One pair of secondary or optic lobes (the so-called first protocerebral lobes).			
	One pair of middle or second protocerebral lobes.	One pair of median (inner) or third protocerebral lobes.				
Ganglionic composition in relation to segment.	Labral ganglion (or first ganglion of head).	Preantennary ganglion (or second ganglion of head).	Not a true ganglion (and, therefore, of no segmental significance).	Antennary ganglion (or third ganglion of head).	Intercalary ganglion (or fourth ganglion of head).	Represents one body segment.
Number of rows of primary neuroblasts taking part.	3-4	4-6	Nil.	4-5	4-5	4-5

homologous with true segmental ganglia. Their connection with the rest of the brain is purely secondary and, therefore, in appraising the primary ganglionic constitution of the brain and the segmental composition of the head, they should be left entirely out of account.

(β) *The other two lobes.*—The second and third lobes may now be considered. *Each* of these lobes develops in a manner strictly homodynamous with a segmental ganglion of the ventral nerve chain. It is significant that the separation between the two lobes is noticeable from the very beginning of their appearance. As development proceeds, this separation becomes accentuated by the formation of an ectodermal inpushing in between the lobes. Moreover, whereas the number of rows of the primary or mother neuroblast cells sharing in the formation of each half of a ganglionic pair of the ventral nerve chain is 4 or rarely 5, *double* this number of rows of neuroblasts (about 8) is found in the two protocerebral lobes of each side taken together—4–6 in the third lobe and 3-4 in the second lobe. These facts suggest almost beyond doubt that *each* of the two protocerebral lobes, and not the whole of the protocerebrum, is homologous with a segmental ganglion of the ventral nerve chain. Consequently, the optic lobes being left out of account, the *protocerebrum must be regarded as being primarily composed of two pairs of true ganglia*, i.e., *of two neuromeres.* By virtue of their position, the median or inner pair of these ganglia (third pair of protocerebral lobes) is to be regarded as belonging to the second or preantennary segment of the head, and the middle or outer pair (second pair of protocerebral lobes) to the first or labral segment (Table 1).

(γ) *Comparison with* Scolopendra.—It is instructive to compare the structure of the insect brain, as interpreted above, with that of *Scolopendra* as elucidated by HEYMONS (1901). According to this author, the supracesophageal ganglion of *Scolopendra* is formed of the pro-, meso- and metacerebrum which are composed of the parts given below in Scheme 1.

I—Front brain = Protocerebrum (*sensu lato*).

- Procerebrum
  - Syncerebrum
    1. Archicerebrum. (Unpaired.)
    2. Lamina dorsalis cerebri. (Paired.)
    3. Lobi frontalis. (Paired.)
    4. Lobi optici. (Paired.) (Not true ganglion.)
  - Protocerebrum
    5. Protocerebrum(*sensu stricto*). (Paired, and belonging to the preantennary segment.)

II—Middle brain = Deutocerebrum.

- Mesocerebrum
  1. Lobi olfactorii seu antennales. (Paired and belonging to the antennary segment.)

III—Hind brain = Tritocerebrum.

- Metacerebrum
  1. Lobi tritocerebrales seu postantennales. (Paired and belonging to the intercalary segment.)

Scheme 1.—The composition of the brain (supraœsophageal ganglion) of *Scolopendra*, according to HEYMONS (1901).

If we compare this condition with that of insects (e.g., *Locusta*; *Forficula*), a certain similarity becomes apparent. With regard to the homologies of the deuto- and tritocerebrum in the two groups, I am in agreement with HEYMONS (1901); but with regard to the homologies of the brain components lying anterior to these, I greatly differ (Table 2).

The unpaired anteriormost ganglion of the embryo of *Scolopendra* is regarded by HEYMONS as being represented by the anterior portion of the supraœsophageal commissure in insects. I disagree with this view. It would be more in consonance with the known facts if we were to believe that during the course of evolution the annelidan prostomium and its neuromere, the archicerebrum, undergo a progressive degeneration. Thus, in *Scolopendra* we still find a well marked 'archicerebrum' and the prostomium is reduced but clear as the 'acron'. In insects, reduction goes still further. The 'archicerebrum' completely disappears, but the prostomium is retained in some as the 'acron', although it disappears in most insects. It would be of extreme interest if a vestigeal 'archicerebrum', somewhat akin to that of *Scolopendra*, were discovered in some

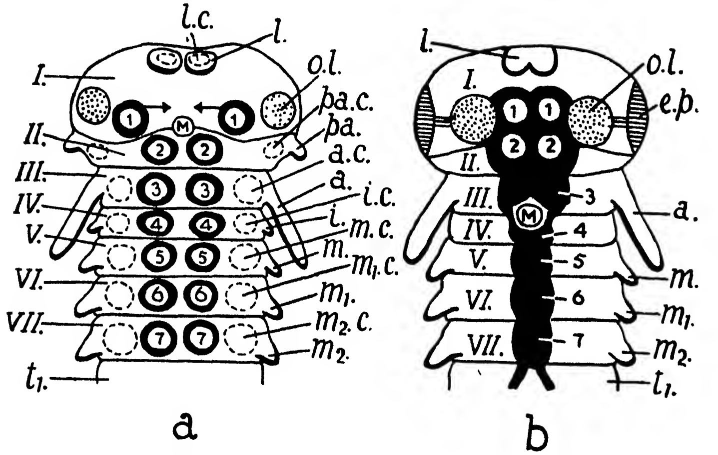
TABLE 2.

The homologies of the various components of the brain in the Myriapoda (Scolopendra) *and the Insecta.*

Brain of Myriapoda (*Scolopendra*) (HEYMONS, 1901).	Brain of Insecta.		
	HEYMONS (1901).	ROONWAL (present account).	
		Composition.	Remarks.
Archicerebrum (= prostomial archicerebrum of Annelida).	Anterior portion of the supra-œsophageal commissure.	Disappears	These together form the insectan proto-cerebrum.
Lobus opticus	First protocerebral lobe or optic lobe.	First protocerebral lobe or optic lobe. (Is not a true ganglion.)	
Lobus frontalis	Second protocerebral lobe ..		
Lamina dorsalis cerebri ..	Third protocerebral lobe ..	Second protocerebral lobe or labral ganglion.	
Protocerebrum (*sensu stricto*) ..	(Not yet demonstrated) ..	Third protocerebral lobe or preantennary ganglion.	
Deutocerebrum	Deutocerebrum	Deutocerebrum	....
Tritocerebrum	Tritocerebrum	Tritocerebrum	....

insect—it should be looked for in the Apterygota and the more primitive of the Pterygota.

The *lobus opticus* and the *lobus frontalis* of *Scolopendra* are regarded by HEYMONS as homologous with the first and second protocerebral lobes respectively of insects. During development, the *lobi opticus* and *frontalis* are intimately associated with each other, and HEYMONS himself remarks that the former probably arises in part from the latter. I am, therefore, inclined to regard both those *lobi* of *Scolopendra* as equivalent to the first protocerebral lobe (optic lobe) of insects which, as shown above, is not homodynamous with a true ganglion.



Text-fig. 3 (*a*) (*b*). Theoretical diagrams of the anterior region of insect embryos, showing the 7-segmental nature of the insect head. Nerve ganglia are shown in heavy black, and cœlom sacs in broken lines. The optic lobes are shown in stipple as they are not homodynamous with the nerve ganglia. (*a*) Early stage. All the cœlom sacs and appendages of the head are seen. The nerve ganglia show their paired origin. The arrangement of the first two pairs of ganglia, *viz.*, those of the labral and proantennary segments, differs from the rest. Arrows indicate the direction of subsequent migration of the first or labral pair of ganglia. (*b*) Later stage. The paired nature of the nerve ganglia is partly lost. The cœlom sacs and the preantennary and intercalary appendages disappear. The oral aperture shifts backwards. The protocerebrum arises by the fusion of the first (labral) and second (proantennary) nerve ganglia and the optic lobes. The medial concentration of the appendages is not shown. (ORIGINAL.)

a., antenna; *a.c.*, antennary cœlom sac; *e.p.*, eye-plate; *i.*, intercalary or premandibular appendage; *i.c.*, intercalary cœlom sac; *l.*, labrum; *l.c.*, labral cœlom sac; *M.*, oral aperture; *m.*, mandible; m_1., first maxilla; m_2., labium; *m.c.*, mandibular cœlom sac; m_1.*c.*, first maxillary cœlom sac; m_2.*c*, labial cœlom sac; *o.l.*, optic lobe; *pa.*, preantenna; *pa.c.*, preantennary cœlom sac; t_1., first thoracic segment; *1–7*, first to seventh nerve ganglia of head, thus: *1*, labral; *2*, preantennary; *3*, antennary; *4*, intercalary; *5*, mandibular; *6*, first maxillary; and *7*, labial; *I.–VII.*, first to seventh head segments.

The *lamina dorsalis cerebri* of *Scolopendra* is homologized by HEYMONS with the third protocerebral lobe of insects whereas, by its position, it should, in my opinion, be homologized with the second protocerebral lobe (which is the neuromere of the labral segment).

The 'protocerebrum' (*sensu stricto*) of *Scolopendra* has, according to HEYMONS, not been demonstrated in insects, but I would suggest its homologue in the third protocerebral lobe of insects which was first demonstrated long ago by VIALLANES (1891).

(c) *The Labral Segment.*

(i) *The appendages.*

I shall discuss below whether or not the labrum can be regarded as representing the true and paired appendages of the labral segment. Morphologically, the labrum is not an unimportant structure. This is suggested by its wide distribution in the Insecta, Myriapoda and Crustacea, and it is certainly homologous in these three groups. The characters by which we recognize structures as being truly segmental appendages are (i) that they should arise in ontogeny as paired, hollow ectodermal evaginations; and (ii) that each member of the pair should possess a cœlom sac, a portion of which is primarily lodged inside the appendage itself. On this basis, the following points support the appendicular nature of the labrum: (1) Its rudiments are paired in several insects. (2) The occurrence, in a number of insects, of an independent *pair* of cœlom sacs lying inside the labrum. The newly discovered labral cœlom sacs are of great importance in establishing the appendicular nature of the labrum. They bear precisely the same relation to the labrum as do the other cœlomic cavities to their respective appendages. To disregard this evidence would involve the assumption of three independent postulates (ROONWAL, 1937) as follows.—(*a*) That the close association between the labral pair of cœlom sacs and the labrum is purely accidental and of no morphological significance. (*b*) That the labral cœlom was originally unpaired in conformity with the unpaired labrum and that its paired nature is secondary. (*c*) That the very existence of the labral cœlom, whether paired or (theoretically) unpaired, is a secondary phenomenon. All the three postulates appear to be highly improbable.

The following points are generally put forth as disproving the appendicular nature of the labrum, but as will be shown below, and as has been recognized by several other authors, all these objections are without sound foundation :—

1. The labral rudiments, in contrast to those of the other body appendages arise medianally to the neural swellings.—It is now recognized that all the cephalic appendages, particularly those lying towards the anterior and posterior extremities of

the head, undergo, during ontogeny, a concentration towards the median line (ROONWAL, 1939, *a*). The labrum, like its counterpart at the other extremity of the head, the labium, comes to lie on the median line itself, with this difference that while the medial concentration of the labium occurs in ontogeny, that of the labrum may be said to occur, to a very considerable extent, in phylogeny, so that already in the early embryo its paired rudiments arise close to the median line. In some insects this concentration takes place so early in phylogeny that the labrum arises, from the beginning, as an unpaired rudiment in the middle line.

2. The labrum, unlike the other true appendages, is never segmented.—This character is shared by the preantennary, intercalary and several abdominal appendages, all of which are admitted as truly appendicular. Moreover, some of the abdominal appendages, such as those which form the uropods and cerci, even though they persist like the labrum in the adult insect, do not undergo any segmentation.

3. The labrum, unlike the other cephalic appendages, occupies a pre-oral position.—The antennæ of the Onycophora are also pre-oral, and yet are correctly regarded as true segmental appendages (WIESMANN, 1926, p. 154).

It would thus appear that the balance of evidence is in favour of the appendicular nature of the labrum, and this view is accepted here.

(ii) *The cœlomic cavities.*

The occurrence of a pair of cœlomic cavities in close association with the labrum has been recently demonstrated in *Carausius* (WIESMANN, 1926), *Rhodinus* (MELLANBY, 1936) and *Locusta* (ROONWAL, 1937).[1] That these are true and independent cœlomic cavities, there appears to be no doubt. Like the other cœlomic cavities, they are bounded by a layer of mesodermal cells and lie in the hollow of their appendage, the labrum. The only way in which they differ from the others is in their comparatively small size, but this difference cannot obviously be of much significance. The objection of MANTON (1928, p. 455) that the labral cœlom sacs of *Carausius* may represent the original aorta-forming part of the preantennary somite cannot be maintained. She lays stress on the connection between the labral and preantennary cœlom sacs *via* the stomodæal mesoderm. Such connections, by means of solid mesodermal strands, occur in several other head and trunk segments both in *Carausius* and *Locusta*, and are probably of little significance. Moreover, in *Locusta*, while the labral cœlomic cavities are present, there is no trace of the preantennary cœlom, and this condition shows that the former should be considered not as derivatives of the latter, bur rather as independent structures. Again, in *Locusta*

[1] Also in the stone-fly *Pteronarcys* by MILLER (1939), see Appendix, p. 105.

the mesoderm of the labral cœlom sacs of each side is quite independent and is unconnected either with its fellow of the other side, or with the stomodæal mesoderm, or the mesoderm of any other segment.

While clear hollow labral cœlom sacs have been demonstrated in only a few insects, paired mesodermal masses, developing in association with the labrum and indicative of collapsed or disorganized cœlom sacs, have been shown in several insects as follows:—In *Forficula* by HEYMONS (1895, *a*); in *Chalicodoma* by CARRIÈRE and BÜRGER (1897); in some other Hymenoptera by STRINDBERG (1914, *a*); and in *Pieris* by EASTHAM (1930, *b*). In *Forficula* these masses are distinctly bi-layered and there can be little doubt of their being homologous with cœlom sacs. Thus it will be seen that the existence of either the labral cœlom sacs or the paired labral mesoderm masses clearly indicative of their cœlom-sac origin have been found in insects belonging to at least six different orders, *viz.*, Orthoptera, Dermaptera, Hymenoptera, Lepidoptera, Plecoptera and Hemiptera. It is perhaps significant that they are best developed in more primitive orders like the Orthoptera and the Hemiptera and less so in the more specialized orders. For the same reason, the fact that they are ill-developed or absent in orders like the Diptera and the Coleoptera is only to be expected since several of the other cœlom sacs are also suppressed here. They have not so far been demonstrated in the Apterygota.

(iii) *The neuromere.*

It has been shown above that, developmentally, the protocerebrum must be regarded as consisting of *two* neuromeres, *viz.*, the second and third protocerebral lobes. Of these, the second lobe is the labral neuromere and the third lobe the preantennary neuromere (Text-fig. 3). This demonstration completes the evidence in favour of the existence of the labral segment.

It must, however, be pointed out that in post-embryonic life the labrum is innervated from the tritocerebrum and not from the median protocerebral lobes. The existence of this condition would appear to be a serious obstacle in accepting the above view, were it not for the fact that the tritocerebral innervation of the labrum is in all probability a secondary feature in so far as the relation of the neuromere and its segment is concerned. The tritocerebrum belongs, without doubt, to the intercalary and not to the labral segment. As to why the labrum should be innervated not by its own neuromere but by one lying three segments behind it, yet remains to be shown.

(*d*) *The Preantennary Segment.*

WIESMANN (1926) in *Carausius* has been the first, and so far the only, author to demonstrate the existence of a

rudimentary pair of preantennary appendages and cœlom sacs. Both these characters support the existence of a preantennary segment. The recognition of the third protocerebral lobe as the preantennary ganglion (Text-fig. 3) has been mentioned above.

(*e*) *Conclusions.*

It has been shown above that, on embryological criteria, we must accept the existence of both the labral and the preantennary segments in insects. These, together with the five following segments, *viz.*, the antennary, intercalary, mandibular, first maxillary and labial, would indicate a 7-segmental nature of the insect head (Table 3).

The chief difficulty in accepting two segments in front of the antennary one is that the scheme does not easily fit in with the condition regarded as occurring in other Arthropods, particularly other Mandibulata, for two pairs of cœlom sacs and of neuromeres lying in front of the somite of the second antennæ have not so far been demonstrated in them. Indications of the existence of either the one or the other of these two segments are, however, evident. Thus, the preantennary cœlomic cavities of insects (*Carausius*) obviously have their homologue in the cavities bearing a similar name in the Chilopod *Scolopendra* (HEYMONS, 1901); in the precheliceral somite of spiders (KISHINOUYE, 1894) and *Scorpio* (BRAUER, 1895); and finally, in the newly discovered preantennulary cœlomic cavities of the Mysid Crustaceans, *Hemimysis* (MANTON, 1928) and *Mesopodopsis* (NAIR, 1939), and the similar but solid somites of *Nebalia* (MANTON, 1934). Labral cœlom sacs have not yet been found in these instances. Appendages of the 'preantennary' segment have so far been demonstrated only in the Insecta and Chilopoda, but not in the Crustacea and Arachnida.

On the other hand, the cœlomic cavities claimed by PFLUGFELDER (1932) to occur in the clypeus of the Diplopod *Platyrrhacus* would, by virtue of their position in the clypeus, seem to correspond to the labral rather than to the preantennary cœlomic cavities of insects, although PFLUGFELDER inclines to the latter possibility. A second pair of pre-oral cœlomic cavities does not occur in *Platyrrhacus*. As in insects, the labrum could be regarded as the appendage of the first segment.

Regarding the neuromeres, it has been shown above that in *Scolopendra* the *lobi opticus* and *frontalis* together represent the first protocerebral lobe (optic lobe) of insects and do not, therefore, constitute a true ganglion. These, together with the 'archicerebrum', the labral neuromere or *lamina dorsalis cerebri* and the preantennary neuromere or 'protocerebrum *sensu stricto*', of HEYMONS, form the protocerebrum *sensu lato* which is homologous with the entire insectan protocerebran. Thus, for Chilopods at least, the evidence in favour of the existence of two

TABLE 3.

Showing the 7-segmental plan of head segmentation in

Nature of segments	Segment number	INSECTA	
		Segment.	Neuromere.
Primary head segments (procephalonic).	1	Labral[1] (WIESMANN, 1926, MELLANBY, 1936, ROONWAL, 1937; MILLER 1939)[2]	Labral ganglion. [Middle protocerebral lobe. (Second lobe of VIALLANES, 1891.)]
	2	Proantennary[1] (WIESMANN, 1926).	Preantennary ganglion. [Inner protocerebral lobe. (Third lobe of VIALLANES, 1891.)]
	3	Antennary	Deutocerebrum .
	4	Intercalary (premandibular or postantennary).	Tritocerebrum ..
Secondary head segments (gnathocephalonic)	5	Mandibular	Mandibular ganglion
	6	Maxillary	Maxillary ganglion
	7	Labial	Labial ganglion

[1] Authors who have demonstrated the cœlom sacs

[2] See Appendix, p. 105.

T..BLE 3.

the Insecta (cf. *Chilopoda, Diplopoda and Crustacea*).

Cœlom sacs.	Appendages.	CHILOPODA (*Scolopendra*). (Segments).	DIPLOPODA (*Platyrrhacus*). (Segments)	CRUSTACEA. (Segments).
Present	Labrum	Labral (?)	Labral [1] (PFLUGFELDER, 1932)	Labral (?).
Present	Preantennæ. (Are rudimentary and evanescent)	Proantennary [1] (HEYMONS, 1901)	Preantennary (?)	Proantennulary [1] (MANTON, 1928; NAIR, 1939).
Present	Antennæ	Antennary	Antennary	Antennulary (first antennary).
Present	Intercalary (pre mandibular) appendages or post antennæ (Are rudimentary and evanescent).	Intercalary (pre mandibular)	Intercalary. (Not present in *Platyrrhacus*, but found in some other Diplopods)	Antennary (second antennary).
Present	Mandibles	Mandibular	Mandibular	Mandibular.
Present	Maxillæ	First maxillary	First maxillary	First maxillary.
Present	Labium	Second maxillary	Second maxillary	Second maxillary.

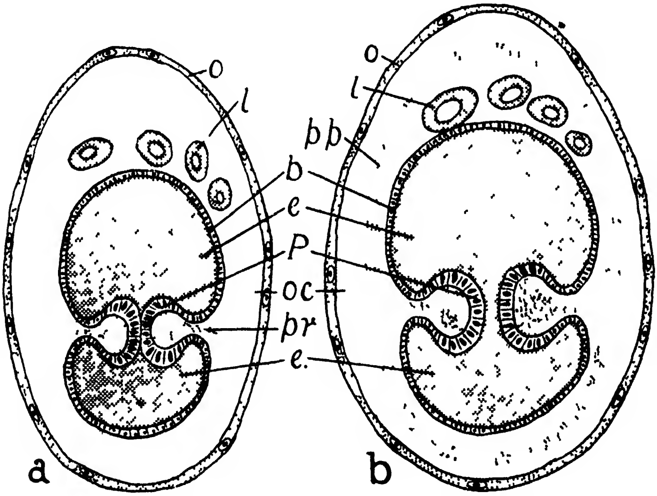
of these segments are given within brackets.

segments lying in front of the antennary one, and thus of a 7-segmental head, is fairly conclusive, with this difference that labral cœlom sacs have not yet been demonstrated. The same, however, cannot be said for the Diplopoda and the Crustacea.

6. THE PLEUROPODIA.

Insect pleuropodia or appendages of the first abdominal segment have a problematic function, variously conjectured as respiratory, secretory and excretory, etc. Recently, however, some information has been forthcoming regarding their function, and it would appear that they may perform variable functions in different insects.

HAGAN (1931) has shown that in *Hesperoctenes fumarius* Westwood, a viviparous Hemipteran belonging to the family Polyctenidæ, the pleuropodia serve as a pseudo-placental organ of the embryo (Text-fig. 4). Several embryos lie freely, as a



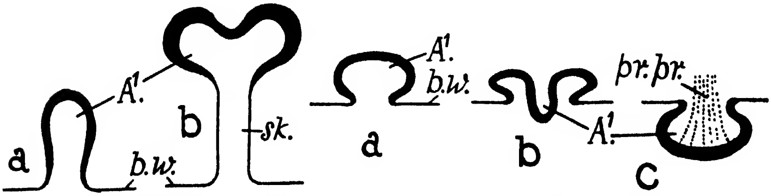
Text-fig. 4 (*a*)–(*b*). Two stages in the development of the pleuropodial pseudo-placenta in *Hesperoctenes fumarius*. Diagrammatic. (*a*) Stage of invaginated pleuropodia which touch each other medially. Note the protoplasmic processes. (*b*) Stage with the completed pleuropodial pseudo-placenta. (*Based on and greatly modified from* HAGAN, 1931.)

b., body-wall of embryo; *e.*, embryo; *l.*, legs; *o.*, wall of maternal genital duct; *o.c.*, cavity of maternal genital duct; *P.*, pleuropodium; *p p.*, pleuropodial pseudo-placenta; *pr.*, protoplasmic processes of pleuropodium.

rule, in the maternal reproductive tracts and the eggs are devoid of yolk. The pleuropodia arise like normal limb-bud evaginations, but shortly before blastokinesis they become invaginated

into the body until the pleuropodia of the two sides touch each other. After blastokinesis, the invaginated pleuropodial cells send out long protoplasmic processes which ultimately surround the embryo completely on the outside and thus form a pseudo-placental organ. Unlike the pseudo-placental organ of the Dermapteran *Hemimerus talpoides* (HEYMONS, 1912) and of the Psocopteran *Archipsocus fernandi* (FERNANDO, 1934), that of *Hesperoctenes* is not directly attached to the maternal body, and the embryo lies quite freely. HAGAN suggests that it absorbs the nutritive fluids from the genital ducts and transports them to the embryo. (Also see p. 53; and Appendix, p. 105.)

Recently, SLIFER (1937) has claimed that the pleuropodia of the grasshopper *Melanoplus differentialis* are the seat of a hatching enzyme which serves to dissolve the tougher portions of the egg-coverings and thus facilitates hatching. The evidence brought forth by her in support of the claim is, however, indirect. By ligaturing the egg above or below the pleuropodia, SLIFER claims to have shown that one of the egg-coverings, *viz.*, the 'white cuticle', is dissolved only in the portion containing the pleuropodia, but remains unaffected in the other half of the egg. When the pleuropodia are removed from the embryo, the 'white cuticle' remains more or less undissolved. From this, she concludes that the pleuropodia secrete a hatching enzyme. While SLIFER'S experiments are suggestive, more work is obviously needed before her claim can be substantiated, especially in view of the fact that the pleuropodia have been shown to undergo, in some other Acridids, *viz* *Stenobothrus* (GRABER, 1888, *a*; 1889, *b*) and *Locusta* (ROONWAL, 1937), a progressive degeneration after blastokinesis until, at the time of hatching, they are reduced to partially cuticularized, shrivelled up masses, apparently of no physiological significance. More recently, SLIFER (1938, *b*) has brought forward some cytological evidence in support of her contention.



(A) Evaginate Type. **(B) Invaginate Type.**

Text-fig. 5 (*A*)–(*B*). Diagrammatic representation of the two main types of development of insect pleuropodia. (*A*)—Evaginate Type. (*B*)—Invaginate Type. (*a*), (*b*), (*c*)—Various consecutive stages of development. (*After* ROONWAL, 1937.)

*A*¹., pleuropodium; *b.w.*, body-wall of germ band; *pr. pr.*, protoplasmic processes of pleuropodium; *sk.*, stalk of pleuropodium.

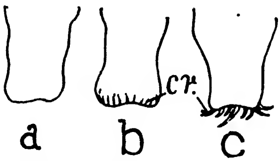
Although a considerable mass of data regarding the development of the pleuropodia exists (*vide* HUSSEY, 1926), no serious attempts had, until lately, been made to classify their various modes of development. Recently, however, ROONWAL (1937) has classified insect pleuropodia into two types: (i) *Evaginate type*, when they remain evaginate throughout their developmental history. Their distal end may undergo a slight invagination, but the latter does not sink beneath the body wall of the embryo. (ii) *Invaginate type*, when they invaginate *into* the body before finally disappearing (Text-fig. 5).

7. THE OTHER ABDOMINAL APPENDAGES.

While the existence of embryonic abdominal appendages, homodynamous with the thoracic legs, has been recorded in most insects, opinion has been somewhat divided firstly, as to their appendicular nature and secondly, as to whether they persist in post-embryonic life, and if so, in what form. The eighth to eleventh abdominal appendages are usually retained as gonapophyses, cerci, etc., while the first seven appendages have generally been regarded as completely disappearing except in the Apterygota where a variable number of them is retained in the adult stage. HAASE (1889, *a*) conjectured that in *Machilis* and *Blatella* (*Blatta*, *Phyllodromia*) some of the anterior abdominal appendages take some share in the formation of the lateral parts (pleuron ?) of the ventral plate and this view was supported by GRABER (1889, *c*; 1890) in *Melolontha*. Modern research has not lent support to this view, but the point deserves careful reinvestigation especially in view of the fact that the thoracic pleura, as will be shown below (p. 56), have been definitely demonstrated to be derived from their respective limb base or subcoxa.

Regarding the prologs of the carterpillars (Lepidoptera) and of the carterpillar-like larvæ of the saw-flies (Tenthredinidæ), KOWALEWSKY (1871), TICHOMIROFF (1882) and GRABER (1890) in *Bombyx* and *Hylotoma*, derived them directly from true abdominal appendages. This view, however, was opposed by others who regarded the prolegs as secondary formations first developed in the larva. KORSCHELT and HEIDER (1892), reconciling these two views, suggested that the embryonic abdominal legs, although disappearing from view, are not completely lost: their vestiges remain latent for a time and later become reactivated in the larva to form the prolegs. The recent work of FRIEDMANN (1934) is, therefore, of interest in finally deciding this point, at least for the Lepidoptera. She has shown that the prolegs of *Chærocampa elpenor* and *Odonestis potatoria* are directly derived from the embryonic abdominal appendages and should, consequently, be regarded as truly appendicular structures (Text-fig. 6). She has seen these transformations in abdominal segments 3–6 and 10. EASTHAM

(1930, *b*) found a similar condition in *Pieris rapæ*. The nature of the abdominal feet of the larvæ of the saw-flies has not



Text-fig. 6 (*a*)–(*c*). Development of the prolegs or abdominal feet of *Odonestis potatoria*. (*a*)—Abdominal appendage of 8½ days old embryo. (*b*)—Same of 9½ days old embryo. The rudiments of the crochets are being laid. (*c*)—Same of 10½ days old (nearly fully developed) embryo. The crochets are complete. (*Adapted from* FRIEDMANN, 1934.)

cr., chrochets.

yet been studied, but it is probable that these structures will be found, as in the Lepidoptera, to be direct derivates of the embryonic abdominal appendages.

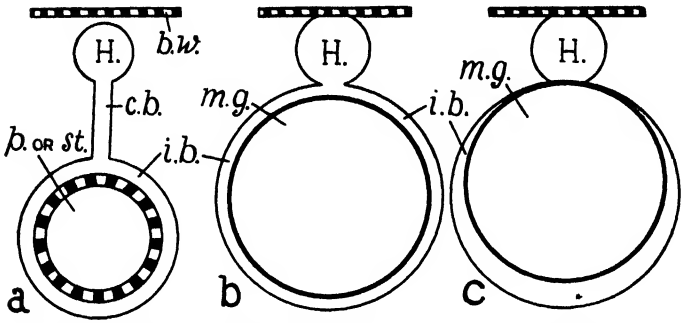
8. THE EMBRYONIC BLOOD SINUSES.

The existence of numerous transient embryonic blood sinuses in insects is of considerable phylogenetic interest when we recall that these sinuses, along with the heart, represent the primitive body cavity or schizocoel of the Annelids, and not the secondary body cavity or cœlom. The definitive body cavity of insects is a hæmocoel which almost completely replaces the cœlom. Of the schizocoelic sinuses in insects, the circum-intestinal blood sinus is of special importance as it is undoubtedly homologous with a similar structure in the Annelids where it is connected with the heart throughout life by means of a long connecting sinus. The various stages by which this connection becomes severed in insects, so that ultimately the circum-intestinal blood sinus remains only as an embryonic organ of recapitulatory and not functional interest, have been recognized by HIRSCHLER (1924) and by ROONWAL (1937). So far, the following three stages have been discovered (Text-fig. 7):—

(*a*) The heart opens into the circum-intestinal blood sinus by means of a long connecting sinus. This condition is found in the distal proctodæal region of *Donacia* (HIRSCHLER, 1909, *a*), and in the distal mesothoracic region of *Locusta* (ROONWAL, 1937).

(*b*) The heart directly opens into the circum-intestinal blood sinus without the intervention of a connecting sinus. This condition occurs in *Carausius* (WIESMANN, 1926).

(c) The heart does not open into the circum-intestinal blood sinus, but merely abuts on the mid-dorsal wall of the latter. This condition occurs in *Locusta* (ROONWAL, 1937) throughout the length of the heart, except in the distal meso-thoracic region where the condition described above in (*a*) obtains.



Text-fig. 7 (*a*) (*c*). Stages in the evolution of the relation between the circum-intestinal blood sinus and the heart in insects. (*a*)—Proctodæal region of *Donacia* or distal mesothoracic region of *Locusta*. (*b*)—Mid-gut region of *Carausius*. (*c*)—Mid-gut region of *Locusta*. (*After* ROONWAL, 1937.)

b.w., dorsal body-wall of embryo; *c.b.*, connecting sinus between heart and circum-intestinal blood sinus; *H.*, heart; *i.b.*, circum-intestinal blood sinus; *m.g.*, mid-gut; *p.*, proctodæum; *st.*, stomodæum.

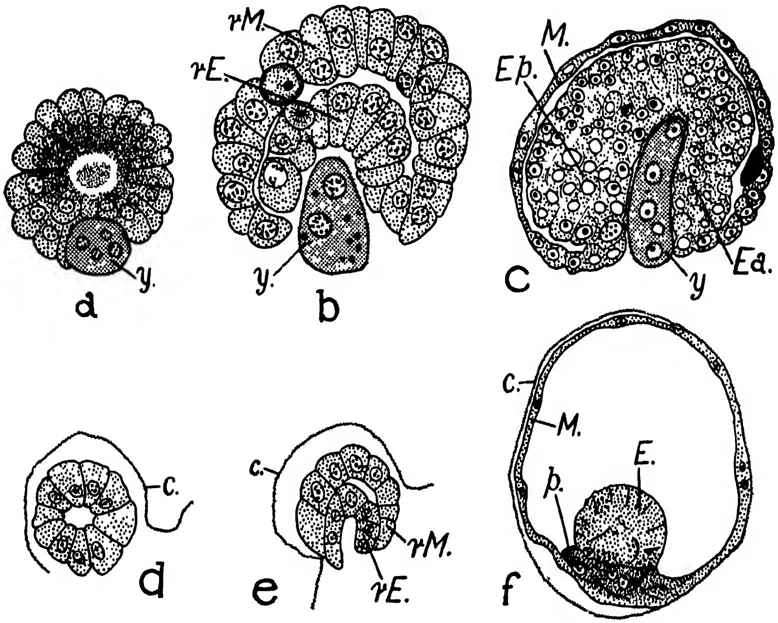
9. POLYEMBRYONY AND THE EMBRYONIC MEMBRANES.

Recent advances in the field of polyembryony and the origin and fate of the embryonic membranes in polyembryonic insects have been summarized by IMMS (1937), and I need not, therefore, go into the subject here.

The persistence of a small portion of the serosa in *Locusta* (ROONWAL, 1935, *b*; 1937) may be mentioned. In this insect, while the greater portion of the serosa degenerates by the formation of a dorsal organ, a small portion of it at the extreme posterior (micropylar) end of the egg remains unaffected. The *posterior serosal patch*, as this structure has been termed, actually undergoes further development by becoming bi-layered and thus developing a cavity. This arrangement persists until hatching when the posterior serosal patch is cast off with the egg-shell. In no other insect has such a structure been described and its significance is as yet obscure.

NOSKIEWICZ and POLUSZYNSKI (1928) have shown that in *Stylops* (Strepsiptera) there is formed only one embryonic membrane which they regard as equivalent to the amnion plus

serosa of other insects. It may be mentioned that this condition strongly recalls the one described long ago by SCLATER (1888) in *Peripatus imthurni* (Onycophora) in his so-called pseudo-gastrula [1], with this difference that unlike as in *Stylops*, the embryonic 'cup' of *Peripatus* does not hold any yolk in its hollow (Text-fig. 8) (also see p. 27). As pointed out by KORSCHELT



Text-fig. 8 (*a*)–(*f*). Figures showing the formation of the embryonic membrane.

(*a*)–(*c*)—*Stylops* sp. (The figures have been turned upside down for facility of comparison with *Peripatus*.) Note the extruded yolk mass. (*a*)—Blastula-like stage. (*b*)—The cup-like stage, showing the differentiation of the germ band proper and the embryonic membrane. (*c*)—Later stage. (*Adapted from* NOSKIEWICZ and POLUSZYNSKI, 1928.)

(*d*)–(*f*)—*Peripatus imthurni.* (*d*)—Blastula-like stage. (*e*)—The cup-like stage (pseudo-gastrula of SCLATER) showing the differentiation between the embryo proper and the embryonic membrane. (*f*)—Later stage. (*After* SCLATER, 1888.)

c., cuticular (?) membrane bounding the maternal uterus internally; *E.*, embryo proper; *Ea.*, anterior end of embryo; *Ep.*, posterior end of embryo; *M.*, embryonic membrane; *p.*, placenta-like growth of cells; *rE.*, rudiment of embryo; *rM.*, rudiment of embryonic membrane; *y.*, extruded yolk mass.

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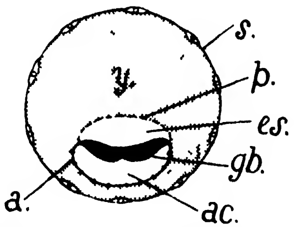
[1] KENNEL (1885; 1888) interpreted a similar condition in *Peripatus edwardsii* in an entirely different way which is probably wrong. He regarded the outer membrane of SCLATER as a derivative of the maternal uterine epithelium. WILLEY'S (1898) observations on *Peripatus novæ-brittaniæ* would appear to support SCLATER'S view.

and HEIDER (1899), the single embryonic membrane of *Peripatus imthurni* might supply a clue to the origin of the double embryonic membranes, the amnion and the serosa, of insects. The condition in *Stylops* strongly supports this suggestion.

10. THE PROVISIONAL DORSAL CLOSURE OF THE EMBRYO.

It is well known that the definitive dorsal closure of the embryo is completed by the germ band ectoderm. Before this, however, the majority of insect embryos undergo a provisional dorsal closure formed by the amnion, the serosa, or both these membranes. This provisional dorsal closure is then replaced by the germ band ectoderm.

In the Acrididæ a remarkable type of provisional dorsal closure has been found. GRABER (1888, *a*) first discovered in *Stenobothrus variabilis* that the lateral edges of the young germ band give rise, at a point slightly above the origin of the amnion, to an ectodermal outgrowth which soon forms a provisional dorsal closure of the embryo, cutting off the latter from the yolk and enclosing an epineural sinus. ROONWAL (1937) has confirmed this in *Locusta* (Text-fig. 9) and has further shown that it repre-



Text-fig. 9. Diagrammatic representation of a transverse section of the early embryo of *Locusta*, showing the early or first provisional dorsal closure. (*Based on* ROONWAL, 1937.)

a., amnion; *ac.*, amniotic cavity; *es.*, epineural sinus; *gb.*, germ band; *p.*, provisional dorsal closure; *s.*, serosa; *y.*, yolk.

sents only the *first provisional dorsal closure*, and is followed by others. The fate of the first provisional dorsal closure of *Locusta* is remarkable. At first it serves as a gliding surface beneath which the splanchnic mesoderm progresses medianally. After some time the splanchnic mesoderm separates from the first provisional dorsal closure at the lateral edges of the germ band, and in this way the first pair of lateral embryonic blood sinuses are formed. The blind ends of the stomodæum and the proctodæum are also closely attached to the first provisional dorsal closure. During blastokinesis the portion of the first provisional dorsal closure lying between the blind ends of the stomodæum and the proctodæum snaps at the edges and grows round the yolk in the same way as the amnion lying dorsal to the embryo

and the portion of the serosa lying anterior to the latter. Its pre-stomodæal and post-proctodæal portions remain unchanged until sometime after blastokinesis when they probably degenerate, being replaced by the definitive dorsal closure formed by the hypodermis. Mid-dorsally, the first provisional dorsal closure is fused with the amnion, the latter forming the *second* or *amniotic provisional dorsal closure* of the embryo. The first provisional dorsal closure at this stage forms the *first provisional mid-gut epithelium.* Afterwards, the splanchnic mesoderm grows round the yolk and separates the first provisional dorsal closure from the amnion. The first provisional dorsal closure then degenerates, leaving the inner layer of the splanchnic mesoderm as the *second provisional mid-gut epithelium* until the definitive mid-gut epithelium is formed from the 'end-ectodermal masses', as has been mentioned above. The second or amniotic provisional dorsal closure of the embryo is soon replaced by the *definitive dorsal closure* formed by the extension of the lateral ectoderm. Thus, two provisional dorsal closures are formed in some insects, the first one of these being peculiar to the Acrididæ.

11. Blastokinesis.

(a) *Mechanism of Blastokinesis.*

Some precise knowledge has accumulated recently regarding the mechanism of blastokinesis. Slifer (1932, *a*), Thompson (1934) and Roonwal (1937) have observed it in the living eggs of representatives of the family Acrididæ. In *Locusta* (Roonwal), about two to three hours (at 33°C.) before the beginning of blastokinesis, peristaltic movements originating at the caudal and proceeding towards the cephalic end of the embryo are seen. At the same time, the entire embryo pulsates in such a way that its dorsal surface abutting on the yolk expands and contracts. Each pulsation lasts for about 1 to 2 seconds, with intervals of 3 to 6 seconds between succeeding pulsations. The peristaltic movements cause the head of the embryo to strike against the embryonic membranes and rupture them. The latter contract on rupturing and the embryo now turns round the posterior pole of the egg and reaches its dorsal surface. Slifer found also that in *Melanoplus femur-rubrum* the embryo after completing revolution ' turns slowly on its long axis until its ventral portions lie beneath the concave surface of the egg'. In *Locusta* blastokinesis takes, when it proceeds smoothly, about 17–20 hours for its completion at 33°C. Sometimes, however, it stops for several hours at various stages of the process and may take nearly double the above time. In *Melanoplus* Slifer found that blastokinesis may be partially gone through even though the serosa remains unruptured. She also found that, in exceptional

cases when blastokinesis fails to occur, development may continue inspite of this defect and a normal animal result.

THOMPSON (1934) has made a detailed study of the rhythmic contractions of the lateral body walls of the embryo of *Melanoplus femur-rubrum*. The contractions commence during blastokinesis and are synchronous with the heart-beats when the latter make their appearance. These activities fall into three chronological periods: (i) From blastokinesis to yolk engulfment, in which the movements are slow, being of the order 15–20 per minute at 25°C., are at times irregular and may even exhibit reversibility in the direction of movement. (ii) From yolk engulfment to nearly the moment of hatching, in which the rate of the contractions increases rapidly to 120–150 per minute. (iii) A period during which this high rate of contraction is maintained at a fairly constant level.

(*b*) *Theories of Blastokinesis.*

Little exact knowledge exists regarding the physiological significance of blastokinesis, but a number of theories have been put forth and are briefly described below:—

1. *Illusion theory.*—Some of the earlier authors believed that blastokinesis is not an active process but an illusion caused by the development of the various body parts in such a way that the embryo seems to undergo a change of position. In view of the fact that vigorous movements of the embryo take place during and just before blastokinesis, and that the revolution of the embryo has now been established beyond doubt, this theory has no foundation.

2. *Chemical theory.*—WHEELER (1893) suggested that the embryo turns in order to get away from the waste products of metabolism and to go to a 'healthy' territory of the yolk. The objections to this view are (i) that waste products can diffuse throughout the egg, and (ii) that several insects undergo no blastokinesis.

3. *Spatio-mechanical theory.*—TIRELLI (1931, *a*) suggested that the silk-worm embryo turns in order to give more space to the dorsal side. In the pre-blastokinetic period, the ventral side of the embryo is convex and, therefore, provides a greater space for the development of the organs than the dorsal side which remains comparatively undeveloped for a long time. At a critical stage, when the development of the ventral side is more or less complete, the embryo turns round so as to give more space to the dorsal side which then becomes convex. This hypothesis has been accepted by GRANDORI (1932, *a*).

It must, however, be admitted that we are still far from fully understanding the true significance of blastokinesis.

12. Viviparity.

Various types of viviparity had been known in insects since a long time, but no satisfactory classification of these types existed. The classification recently proposed by Hagan (1931), therefore, serves a very useful purpose. Four types of viviparity, depending largely on the nutritive arrangements of the embryo, have been recognized by Hagan, and the last type has been further subdivided here into a number of classes. The various types are described below :—

1. *Ovo-viviparity.*—The egg contains a sufficient amount of yolk to nourish the embryo until hatching. The larva, until it is extruded by the mother, does not receive additional nutriment from specialized organs. Examples: Some Coccidæ; some Coleoptera; Sarcophagidæ; the Psocopteran, *Hyperetes guestphalicus* (Jentsch, 1936); and others.

2. *Intussuctio-viviparity.*—The egg contains a sufficient amount of yolk to nourish the embryo until hatching. The larva is retained in the maternal uterus and is nourished by means of secretions from specialized organs, such as uterine glands, of the mother. No placenta-like organs are formed. Examples: *Glossina*; some Muscidæ; and the Pupipara.

3. *Exgenito-viviparity.*—The egg contains little or no yolk. The embryo, in a stage of development corresponding to the egg stage of the ovo-viviparous forms, obtains its nourishment directly from the maternal tissues by means of a trophamnion, tropliserosa, or trophchorion. Development occurs in the maternal hæmocoel and not in the genital tract. Examples: Strepsiptera.

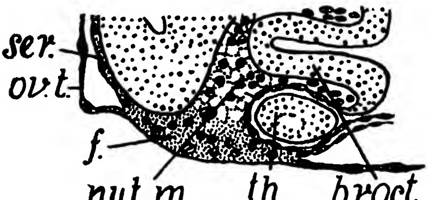
4. *Pseudoplacento-viviparity.*—The egg contains little or no yolk. The embryo develops in the genital ducts of the mother and receives from the latter, at least for some time, a supply of nutriment by means of a placenta-like organ called the pseudo-placenta. Examples: *Hesperoctenes* (Hemiptera); *Hemimerus* (Dermaptera); *Archipsocus* (Psocoptera); and others. Under this head, I propose the following further sub-types:—

(a) *Attached embryo type.*—In this case the embryo is attached by means of the pseudo-placenta to the maternal body for a varying period. This is further divisible into the following three types depending on the origin of the pseudo-placenta which may arise as follows!

(i) *Exclusively from the maternal tissues.*—In the parthenogenetic eggs of viviparous aphids, Will (1888) showed that after the development of the 'blastoderm', the egg contains only a small amount of food-yolk—the

so-called 'primary food yolk'—in which a few yolk cells are found. This yolk soon disappears. Subsequently, however, the embryo is provided by a fresh mass of yolk—the so-called 'secondary yolk or pseudo-vitellus'—through the development of a kind of pseudo-placental outgrowth from the maternal follicular epithelium which penetrates the embryo through a gap (wrongly called 'blastopore' by WILL) in the 'blastoderm' and ultimately fuses with the latter. By a disintegration of the pseudo-placental cells, there arises the 'secondary yolk' which comes to lie in the primary body cavity of the embryo and into which the already present yolk cells of the embryo wander. After a time the connection of the pseudo-placental 'secondary yolk' with the maternal follicular epithelium is severed.

(ii) *Exclusively from the embryonic tissues.*—So far only the embryonic membranes have been known to form the pseudo-placenta. In *Archipsocus fernandi* (FERNANDO, 1934) it arises from the serosa in the posterior region (Text-fig. 10), and from both the amnion and



Text-fig. 10. Portion of sagittal section of posterior region of the embryo of *Archipsocus fernandi*, showing the connection of the serosa with the maternal ovarian tubule. (*After* FERNANDO, 1934.)

f., region of the fusion of serosa with wall of ovarian tubule; *nut.m.*, nutritive mass; *ov.t.*, wall of ovarian tubule; *proct.*, wall of proctodæum; *ser.*, serosa; *th.*, thoracic leg.

the serosa in the anterior region. In both these regions the membranes fuse with the ovarian wall.

(iii) *Both from the embryonic and the maternal tissues.*—In *Hemimerus talpoides* (HEYMONS, 1912) the pseudo-placenta is formed largely by the amnion, but in part probably by the maternal tissue also. This condition would, therefore, appear to occupy an intermediate

position between (i) and (ii) mentioned above, although it must be pointed out that the three kinds of pseudo-placentæ have been, in all probability, evolved quite independently of one another.

(b) *Free embryo type.*—In this case the embryo lies freely in the maternal genital ducts and is not fixed in any way to the latter. The pseudo-placenta is formed, so far as is known, by the pleuropodia, as in *Hesperoctenes* (HAGAN, 1931) discussed above (p. 44). The pseudo-placenta has no direct connection with the maternal ovarian wall and only serves to absorb the nutritive fluids present in the oviduct. (Also see Appendix, p. 105.)

13. THE GENITAL CELLS.

The genital cells of insects are usually differentiated after the formation of the mesodermal somites and, indeed, from the latter. In numerous cases, however, they arise very early—sometimes during or even before cleavage—and then undergo a period of rest before acquiring their definitive position on the mesodermal somites and again becoming active. It is, therefore, desirable that we should be able to distinguish the exact point of time, in relation to other embryonic processes, when the genital cells arise. For this purpose, the following classification, where the insectan genital cells have been classified in accordance with the time of their appearance, has been proposed (ROONWAL, 1939, *b*). The classification is a modification of that originally proposed by SHINJI (1924).

1. *Pre-cleavage differentiation.*—Before cleavage begins. It is a kind of chemo-differentiation of the periplasm and, consequently, does not involve discrete cell or cell-like masses of protoplasm. It occurs in some Diptera, Coleoptera and probably the parasitic Hymenoptera.

2. *Cleavage differentiation.*—During cleavage. It occurs in some Diptera, such as *Chironomus* and *Miastor*.

3. *Post-cleavage differentiation.*—(Blastodermic differentiation of SHINJI.) After the end of cleavage but before the differentiation of the inner layer. It occurs in *Isotoma* (Collembola), *Forficula* (Dermaptera), *Vanessa* (Lepidoptera) and in some aphids and coccids.

4. *Differentiation from the inner layer.*—(Mesodermic differentiation of SHINJI). Undoubtedly from the mesodermal elements of the inner layer. It occurs in most Pterygota.

14. THE BODY SCLERITES.

Embryology has recently thrown some light on the origin of two of the body sclerites, and these will be considered below.

(*a*) *The Basal Sclerites of the Labium.*

The difficulty of the homology of the basal sclerites of the labium has been discussed recently by SNODGRASS (1935), IMMS (1937) and others. Several writers have suggested, on morphological grounds, that while the mentum is of an appendicular origin and corresponds to the fused cardines of the first maxilla, the submentum is not truly appendicular but belongs to the sternal region of the labial segment.

Recent embryological evidence is entirely against this view. ROONWAL (1937) has shown that in *Locusta* no portion of either the labial or the prothoracic sternum takes part in the formation of the labial base, and the posterior border of the submentum represents the true anterior boundary of the prosternum. The labial sternum fuses with the two preceding sterna to form the hypopharynx. The mentum does not exist as a separate sclerite in *Locusta* but is probably fused with the submentum.

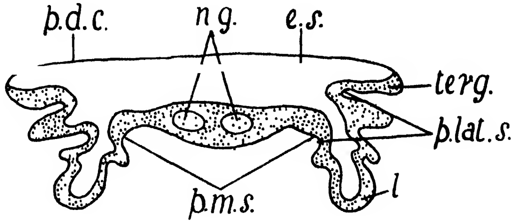
HOLMGREN (1909) maintained, also on embryological grounds, that the submentum of *Eutermes* is derived from the articulatory membrane between the labial and the first thoracic segments and, ontogenetically, is not a part of the labium. This view is at variance with the above-mentioned observations on *Locusta*. According to HEYMONS (1899), in Hemipteran embryos the various portions of the jaw appendages, such as the lacinia, galea, palpus, etc., arise independently and unite together secondarily to form the complete jaw appendage. No subsequent worker has confirmed this remarkable claim and it is difficult to accept it at present.

(*b*) *The Pleura* (Text-figs. 11 and 12).

HEYMONS (1899) first showed, on embryological evidence from the Hemiptera, that the insectan pleura in the thoracic region arise either wholely or in part from the subcoxa of their segments. Subsequently, several authors claimed this on purely morphological grounds (*vide* IMMS, 1937), and thus arose the 'subcoxal theory' of the origin of the pleuron. It is obvious that in deciding a problem of this nature, reference must be made to embryology, but for a long time HEYMONS's paper stood alone in this respect. Recently, however, ROONWAL (1937) has provided support for this theory from the condition obtaining in *Locusta* embryos, as will be evident from the following description taken from that author:—

The first division of each typical segment of the body (Text-fig. 11) is into a median sternum and two lateral *primary tergal sclerites*. The sternum is divisible into a median portion termed the *primary medio-sternite*, and two lateral portions, the

primary latero-sternites[1]. The latter bear the appendages. The above description applies from the mandibular to the tenth abdominal segments, but what follows refers to the thoracic segments only. After blastokinesis the lateral edges of the embryo grow round and unite in the mid-dorsal line, thus forming a complete or *definitive tergum*. The articulations of the



Text-fig. 11. Diagrammatic representation of a transverse section across the metathorax of an embryo of *Locusta migratoria migratorioides* R. & F., shortly before blastokinesis, showing the primary tergal and sternal sclerites. (*After* ROONWAL, 1937.)

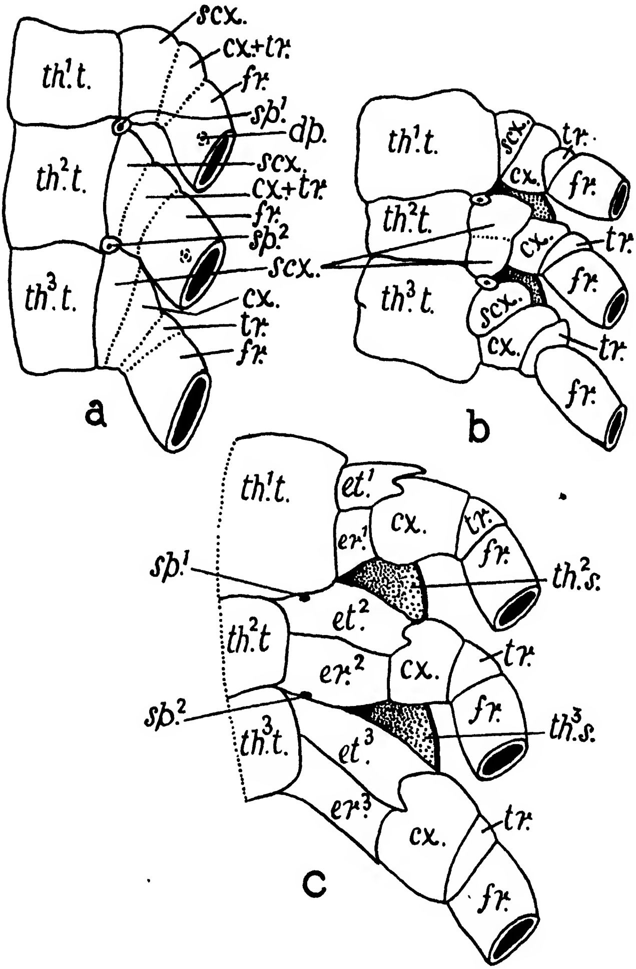
e.s., epineural sinus; *l.*, metathoracic leg; *n.g.*, nerve ganglia; *p.d.c.*, first provisional dorsal closure of embryo; *p.lat.s.*, primary latero-sternite; *p.m.s.*, primary medio-sternite; *terg.*, primary tergal sclerite.

legs with the body move laterally and come to lie at the junction of the tergum with the sternum. At the same time, the subcoxal joint of the thoracic legs grows and forms a large sclerite, the pleuron, between the tergum and the sternum (Text-fig. 12). Each pleuron further becomes divided into an anterior sclerite or episternum, and a posterior sclerite or epimeron. The episternum of the prothorax becomes prolonged into a short spine over the coxa. In this way the *entire* pleuron in each of the thoracic segments of *Locusta* arises from the subcoxa of its segment.

15. THE CORPORA ALLATA.

All workers are agreed that the corpora allata first arise as invaginations of the head ectoderm, but the position of these invaginations apparently varies in different insects. Thus, in *Forficula* (HEYMONS, 1895, *a*) they arise from the base of the first maxillæ; in *Apis* (NELSON, 1915) from the mandibular segment; in *Pieris* (EASTHAM, 1930, *b*) from the mandibular apodeme; and in *Carausius* (WIESMANN, 1926) and *Locusta* (ROONWAL, 1937) from the intersegmental membrane between the mandibular and the first maxillary segments.

[1] The term 'primary latero-sternites' is to be distinguished from the term 'latero-sternite' employed by the morphologists. Thus, SNODGRASS (1935) uses the latter term to denote the lateral portion of the definitive thoracic sternum 'apparently derived from the ventral arc (sternopleurite) of the subcoxa'.



Text-fig. 12 (*a*)–(*c*). Thoracic regions of embryos of *Locusta migratoria migratorioides*, R. & F. viewed from the side, showing the origin of pleura from the subcoxa. The legs are shown in part only. (*a*)—From embryo 120 hours old (at 33°C.). (*b*)—From embryo 7 days old, *i.e.*, one day after blastokinesis. The mesothoracic subcoxa is seen dividing into an upper or episternal portion and a lower or epimeronic portion of the future pleuron. (*c*)—From a freshly hatched female hopper. (*After* ROONWAL, 1937.)

cx., coxa; *dp.*, minute, evanescent femoral depressions of problematic significance; *et*^{1}.–*et*^{3}., episternum of 1st to 3rd thoracic segments; *er*^{1}.–*er*^{3}., epimeron of 1st to 3rd thoracic segments, *fr.*, femur; *scx.*, subcoxa; *sp*^{1}., *sp*^{2}., first and second spiracles; *th*^{2}.*s.*, *th*^{3}.*s.*, meso- and metathoracic sternum; *th*^{1}.*t.*–*th*^{3}.*t.*, 1st to 3rd thoracic terga; *tr.*, trochanter.

However, in a recent work TIEGS and MURRAY (1938) have claimed that in the beetle *Calandra oryzae* the corpora allata are derived from the walls of the antennary cœlom sacs. In other words, they are mesodermal in origin. Now, in several insects it has been clearly shown that while these organs first arise undoubtedly as ectodermal structures, they later become invested with a thin mesodermal coat from the inner walls of the antennary cœlom sacs. In older stages it is difficult to distinguish this mesodermal covering from the ectodermal portion. TIEGS and MURRAY have probably failed to distinguish between the ectodermal origin of these organs and their secondary association with the antennary mesoderm, and it is difficult to accept their unique claim until adequate confirmation is forthcoming.

16. SOME EMBRYOLOGICAL PROBLEMS.

While a detailed study of the embryology of almost any insect is likely to yield new and valuable information, some important lacunæ in our knowledge of this subject and certain special lines of fruitful investigation may be mentioned.

First of all, some of the primitive or otherwise interesting orders have not been worked out at all. These are: the Protura among the Apterygota; and the Mecoptera among the Pterygota. Among certain others, such as the Plecoptera, Isoptera, Embioptera, Psocoptera, Anopleura, Ephemeroptera, Thysanoptera, Neuroptera, Strepsiptera and the Aphaniptera, while some work has been done, further and fuller information is greatly needed. Thus, in the Strepsiptera, for example, HOFFMANN (1914) and NOSKIEWICZ and POLUSZYNSKI (1928) have obtained results of such great interest, especially with reference to early development and gastrulation, that one can confidently predict further important results in this group.

The early development of the parasitic Hymenoptera, especially the polyembryonic groups, and the precise origin of the embryonic envelops in them, is a subject calling for enquiry.

The accumulation of embryological evidence in regard to head segmentation is another important subject of research interest in which has recently been rekindled by the discovery of labral and preantennary cœlom sacs in *Carausius* and of the former alone in *Rhodinus* and *Locusta*.[1] It would consequently be of very great interest to investigate the cephalic cœlom sacs and the development of the brain in the other Orthoptera as well as in other primitive insects.

The precise and detailed mode of differentiation, stage by stage, of the germ layers would provide extremely welcome information. It is essential that every event, however fleeting

[1] Also *Pteronarcys*, see Appendix, p. 105.

and apparently insignificant, in this process should be recorded as otherwise, we shall not be able to get beyond the stereotyped accounts of embolic and epibolic gastrulations which are only too well known. Before leaving early development, it may be pointed out that the kinetics of the cleavage cells, *i.e.*, their division and migration rates, the proportion of the primary yolk cells to other cleavage cells, and such other phenomena, have been so far investigated in very few insects, and more work is desirable in this field.

The rôle of the embryonic abdominal appendages in the formation of the uropods has been investigated in but few insects. The eighth and ninth abdominal appendages are generally believed to form the lower and upper ovipositor valves respectively of the female. These and other cognate phenomena must be investigated further before indisputable evidence can be said to have accumulated for the above view.

The origin of the mid-gut epithelium is too well known a problem to need emphasis and any new and exact information on that point cannot but be of interest. The claim of certain recent authors regarding the share which the yolk cells take in mid-gut formation is a point which especially needs confirmation. In this connection it may be mentioned that most authors have not been able to distinguish between primary and secondary yolk cells, although long ago GRABER (1891, *a*) had claimed that in *Melolontha* he could distinguish between the two kinds of yolk cells by their histological characters. This point deserves closer study. What happens to the primary yolk cells when the secondary ones begin to be formed? Do all of them degenerate; and do they become inextricably identified, in their morphology and their fate, with the secondary yolk cells? What is the life of a single yolk cell? Answers to these and other related questions are admittedly most difficult to obtain, but no serious attempts have been made in that direction. The recent work of TIRELLI (1926–1934) and other Italian workers has, however, opened up interesting possibilities in the field.

A critical study of the process of blastokinesis, as has recently been attempted in some grasshoppers and the silkworm, is certain to yield valuable and interesting information if undertaken in other insects.

The origin of some of the body sclerites is a much-discussed problem largely because conclusions have hitherto been derived from theoretical evolutionary pictures based on morphology of the post-embryonic stages only. Embryological evidence, whenever available, has not failed to throw light on these discussions. Thus, the origin of the entire pleuron from the subcoxa and the truly appendicular nature of the labial submentum has recently been conclusively demonstrated in *Locusta*. But the development of these sclerites in other insects must be studied before generalizations of any value can be made.

I have indicated above only a few lines of research in descriptive or spatial embryology which are likely to prove fruitful. Rich subjects like bacterial symbiosis and experimental embryology are beyond the scope of the present work. In the former, BUCHNER and his school in Germany have produced extensive and extremely interesting work. In the latter, we have the pioneer works of HEGNER (1908–1911) in America, GEIGY (1931) in France, and, the most important of all, PAULI (1927), REITH (1925–1935) and of SEIDEL (1926–1936) and his school (KRAUSE, 1934, 1938; SCHNETTER, 1934, *a*, *b*; and MASCHLANKA, 1938) in Germany. In this connection, the helpful review of RICHARDS and MILLER (1937) also deserves mention. These fields, as well as that of embryonic physiology, lie almost virgin to-day and must be attacked.

IV. SUMMARY.

A brief historical sketch of the development of insect embryology; from the days of ARISTOTLE up to modern times, is given.

The carbolic-acid-and-water technique, evolved by SLIFER and KING (1933) has practically solved the difficulty of sectioning large yolky insect eggs.

The amplified theory of multi-phased gastrulation among insects (ROONWAL, 1939 *b*) is described. Its more important features are: (i) the suppression of the blastula stage; (ii) the spatial and temporal elongation of gastrulation and its consequent occurrence in several phases and sub-phases; (iii) the quadruple nature of all the three germ layers which are distinguishable firstly, into primary and secondly portions and secondly, into permanent and evanescent portions; and (iv) the tendency towards the suppression of the primary germ layers.

Some recent authors have shown that yolk cells definitely share in the formation of the mid-gut epithelium of certain insects.

HENSON'S (1932) unique claim of the endodermal origin of the insectan Malpighian tubules has been regarded by most authors as being devoid of foundation, and these structures are believed to be undoubtedly ectodermal.

A curious inversion of cell polarity has been recorded in the early embryos of some Strepsiptera.

Recent embryological evidence tends towards the establishment of two segments—the labral and the preantennary—lying in front of the antennary one, and thus towards the establishment of the 7-segmental nature of the insect head. The demonstration of the labral and the preantennary pair of cœlom sacs in *Carausius* by WIESMANN (1926), and of the former alone in *Rhodinus* by MELLANBY (1936) and in *Locusta* by ROONWAL

(1937)[1], provides support for this theory. A new interpretation of the composition of the insectan protocerebrum is presented according to which it is composed of two neuromeres which are assigned to the labral and the preantennary segments.

The pleuropodia of the viviparous Hemipteran, *Hesperoctenes fumarius* form, according to HAGAN (1931), a pseudo-placental organ. SLIFER (1937 and 1938, *b*) claims that in the grasshopper, *Melanoplus*, the pleuropodia secrete an enzyme which aids in hatching. A new classification of insect pleuropodia into 'evaginate' and 'invaginate' types, based on their development, has recently been proposed.

FRIEDMANN (1934) has shown that the prolegs of the Lepidopteran caterpillars are direct derivatives of the embryonic abdominal appendages and must, therefore, be regarded as true segmental appendages.

Certain embryonic blood sinuses of considerable phylogenetic significance have been recorded in several insects. Their theoretical evolution in relation to the heart or mid-dorsal vessel of insects has been recently envisaged, and is described.

Three embryonic dorsal closures—two provisional and the third definitive—have recently been shown to occur in the Acrididæ. Their relation with the provisional and definitive mid-gut epithelia is intimate.

The precise mechanism of blastokinesis has been recently studied in great detail in certain insects and it has been established that the embryo undergoes blastokinesis by means of active movements of its own body. TIRELLI (1931, *a*) has suggested a spatio-mechanical theory of the origin of blastokinesis. According to it, insect blastokinesis originated owing to the need of the embryo for more space for its developing side.

HAGAN'S (1931) classification of the various types of viviparity among insects is described. A further sub-division of the type 'pseudoplacento-viviparity' is proposed.

A classification of the insectan genital cells, based on the time of their first appearance in the embryo, has recently been suggested.

It has been recently demonstrated that in *Locusta* no portion of either the labial or the prothoracic sternum takes part in the formation of the labial base and the posterior border of the submentum represents the true anterior boundary of the prosternum.

Recent embryological evidence strongly supports the theory of the origin of the thoracic pleura from the subcoxa.

The claim of TIEGS and MURRAY (1938) that the corpora allata in *Calandra* arise from the antennary mesoderm, instead of from the head ectoderm as in all other insects, does not appear to be well founded and cannot be accepted without further confirmation.

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[1] Also in *Pteronarcys* by MILLER (1939), see Appendix, p. 105.

Some embryological problems which call for enquiry and whose study is likely to yield fruitful results, are briefly described.

A complete and classified bibliography of insect embryology is appended.

V. BIBLIOGRAPHY.

An attempt is made here to compile as complete a list as possible of the literature on insect embryology up to the end of the year 1937. Papers appearing during 1938 and the early part of 1939 have also been included, but this period cannot be said to be complete. Notwithstanding my best efforts, a few references might still have been overlooked, and I shall be grateful to readers if they will kindly send me information about these. The majority of the references have been examined mostly in the Balfour and University Libraries, Cambridge; in the libraries of the Kaiser Wilhelm-Institut für Biologie and the Deutsches Entomologisches Institut, Berlin-Dahlem; in the Stattsbibliothek, Berlin; and in the library of the Zoological Survey of India, Calcutta. Those that could not be so examined have been taken from other sources, and I take this opportunity of expressing my gratitude to the numerous friends and workers who have helped me either by sending reprints of their works or in other ways.

To enhance its usefulness, this section is divided into two sub-sections as follows:—

1. Alphabetical List.—In this the author's name, the full title, etc., of the paper, and the journal in which it has appeared are given.

2. Classified List.—In this only the author's name and year, as appearing in the alphabetical list, are given. This sub-section is further divided as follows:

(*a*) *Classified according to insect orders.*

(*b*) *General.*—Under this are included those references which could not be easily classified under (*a*) above because they deal either with several insect orders, or with insects as a whole.

(*c*) *Experimental embryology.*—Under this are included those references which, while dealing mainly with the experimental side, also give observations on general embryology. They are also included under (*a*) above. It may be added that only the more important works have been included, and the list is by no means complete.

(*d*) *Bacterial symbiosis.*—Under this are included those references which, while dealing mainly with bacterial symbiosis in insect eggs, also give valuable

observations on insect embryology. They are also included under (*a*) above.

(*e*) *Other Arthropods, etc.*—Under this are included a few references which, while dealing mainly with the embryology of Arthropods other than insects, deal, in addition, either with certain aspects of insect embryology, or are invaluable for the proper understanding of the latter from the comparative point of view.

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———1891(*b*).—The germ band of Insecta. (A review of Graber's paper.)—*Psyche*, vol. VI, pp. 112–115.

———1891(*c*).—Neuroblasts in the Arthropod embryo.—*Jour. Morph.*, vol. IV, pp. 337–343.

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———1893.—A contribution to insect embryology.—*Jour. Morph.*, vol. VIII, pp. 1–160.

WIELOWIEJSKI, H. R. 1886.—Über das Blutgewebe der Insekten. Eine vorläufige Mittheilung.—*Zeit. f. wiss. Zool.*, vol. XLIII, pp. 512–536.

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WIEMANN, H. L. 1911.—The germ cell determinants of Chrysomelid eggs.—*Science*, vol. XXXIII, pp. 456-457.

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WILL, L. 1883.—Zur Bildung des Eies und des Blastoderms bei den viviparen Aphiden.—*Arbeit. zool.-zoot. Instit., Würzburg*, vol. VI, pp. 217–258.

————1888(*a*).—Zur Entwicklungsgeschichte der viviparen Aphiden.—*Biol. Centralb.*, vol. VIII, pp. 145–154.

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————1899.—Trophoblast and serosa; a contribution to the morphology of the embryonic membranes of insects.—*Quart. Jour. Micr. Sci.*, vol. XLI, pp. 589–609.

WILLIAMS, F. X. 1916.—Photogenic organs and embryology of Lampyrids—*Jour. Morph.*, vol. XXVIII, pp. 145–207.

WITLACZIL, E. 1884.—Entwicklungsgeschichte der Aphiden.—*Zeit. f. wiss. Zool.*, vol. XL, pp. 559–696.

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WOODWORTH, C. W. 1889.—Studies on the embryological development of *Euvanessa antiopa*.—In S. H. Scudder's *The butterflies of the Eastern United States and Canada, with special reference to New England*, vol. I, pp. 95–104, Cambridge.

WRAY, D. L. 1937.—The embryology of *Calendra callosa* Olivier, the Southern Corn Billbug (Coleoptera, Rhynchophoridæ).—*Ann. Entom. Soc. Amer.*, vol. XXX, pp. 361–409.

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ZACHARIAS, O. 1884.—Neue Untersuchungen über die Entwicklung der viviparen Aphiden.—*Zool. Anz.*, vol. VII, pp. 292–296.

ZADDACH, G. 1854.—Untersuchungen über die Entwicklung und Bau der Gliederthiere. I. Die Entwicklung des Phryganideneies. —Berlin.

————1867.—Ueber die Entwicklung der Insekten.—*Schrift kaiserl. phys. oekon. Gesell., Kõnigsberg*, vol. VII.

ZOGRAF, N. (SOGRAFF, N.), 1882.—Zur Embryologie der Chilopoden.—*Zool. Anz.*, vol. V, pp. 582–595.

————1883.—Materials for the study of the embryological development of *Geophilus ferrugineus* L.K. and *Geophilus proximus* L.K. (In Russian.)—*Izwiest. Imp. Obszczestw. Ljubytel. Estestowzn. Antrop., Moscow*, vol. LIII.

————1892.—Note sur l'origine et les parentes des Arthropodes, principalement des Arthropodes tracheates.—*Congr. Internat. Zool.* (*Deuxieme sess., a Moscau*), Part I, pp. 278–302.

2. CLASSIFIED LIST.

(*a*) *Classified according to Insect Orders.*

(A)—APTERYGOTA.

1. Thysanura.

Grassi, B. (1884, *b*); Heymons, R. (1897, *a*, *b*); Heymons, R. and Heymons, H. (1905); Uzel, H. (1897, *a*, *b*); Silvestri, F. (1932).

2. Protura.

No references.

3. Collembola.

Barrois, L. (1879); Carl, F. (1903); Claypole, M.A. (1892; 1898); Folsom, H. (1900); Hoffmann, R. W. (1911); Lemoine, V. (1883); Oulganine, M. [Uljanin, M.] (1875; 1876); Packard, A. S. (1870; 1871, *a*); Philiptschenko, J. (1912, *a*, *b*); Prowazek, J. (1900); Ryder, J. A. (1886, *b*); Uzel, H. (1898).

(B)—PTERYGOTA.

(α) Exopterygota.

4. Orthoptera

Ayers, H. (1884); Baden, V. (1936); Baehr, W. B. Von (1907); Blochmann, F. (1887, *b*); Cappe de Baillon, P. (1920; 1925); Cappe de. Baillon, P. and Pillault, R. (1937); Cholodkowsky, N. A. (1888; 1890, *a*, *b*; 1891, *a*, *c*, *d*); Else, F. L. (1934); Faussek, V. (1911); Giardina, A. (1897); Graber, V. (1888, *a*, *c*; 1890; 1891, *a*, *b*, *e*); Hagan, H. R. (1917); Hallez, P. (1885; 1886); Hammerschmidt, J. (1910); Heymons, R. (1890; 1891, *a*, *b*; 1892; 1895, *a*; 1897, c); King, R. L. and Slifer, E. H. (1934); Korotneff, A. (1883; 1885); Krause, G. (1934; 1938); Lehmann, F. (1925); Leuzinger, H. and Wiesmann, R. (1925); McNabb, J. W. (1928); Nelsen, O. E. (1931; 1934, *a*, *b*); Nusbaum, J. (1883; 1886); Nusbaum, J. and Fulinski, B. (1906; 1909); Oka, H. (1934); Packard, A. S. 1883); Patten, W. (1884); Payne, N. M. (1934); Pflugfelder, O. (1937, *b*); Rabito, L. (1898); Rathke, H. (1832; 1844); Riley, W. A. (1904); Roonwal, M. L. (1935, *a*, *b*; 1936, *a*, *b*; 1937); Slifer, E. H. (1931; 1932, *a*, *b*; 1934; 1935; 1937; 1938, *a*, *b*); Slifer, E. H. and King, R. L. (1933; 1934); Strindberg, H. (1914, *b*); Stuart, R. R. (1935); Thomas, A. J. (1936); Thompson, V. (1934); Viallanes, H. (1890; 1891); Wheeler, W. M. (1889, *a*; 1890, *a*, *c*, *d*; 1893); Wiesmann, R. (1926).

5. Dermaptera.

Hansen, H. J. (1894); Heymons, R. (1893, *a*; 1895, *a*; 1909; 1912); Strindberg, H. (1915, *c*).

6. Plecoptera.

Miller, A. (1939).

7. Isoptera.

Holmgren, N. (1909); Knower, H. M. (1896; 1900); Strindberg, H. (1913, *b*).

8. Embioptera.

Kershaw, W. (1914).

9. Psocoptera.

Fernando, W. (1934); Jentsch, S. (1936); Melnikow, N. (1869).

10. Anoplura (including Mallophaga).

Fernando, W. (1933); Grimm, O. (1870, *a*); Melnikow, N. (1869); Ries, E. (1931); Schlözel, G. (1937); Strindberg, H. (1916, *b*); Swammerdam, J. (1737); Weber, H. (1939).

11. Ephemeroptera.

Heymons, R. (1896, *a*, *c*;) Joly, N. (1876, *a*, *b*).

12. Odonata.

Brandt, A. (1869); Graber, V. (1888, *a*); Heymons, R. (1896, *a*); Packard, A. S. (1868; 1871, *a*); Seidel, F. (1926; 1928; 1929, *a*, *b*; 1931; 1932; 1936); Tschuproff, Mme. H. (1903).

13. Thysanoptera.

Reyne, A. (1927).

14. Hemiptera.

Baker, A. C. (1921); Balbiani, E. G. (1866; 1871, *a*, *b*; 1885); Brandt, A. (1869); Brass, A. (1883); Breest, F. (1914); Buchner, P. (1911; 1918); Canto, P. (1896); Fijalkowska, J. (1928); Gillardi, H. (1934); Graber, V. (1878; 1888, *a*); Hagan, H. R. (1931); Henking, H. (1891, *a*); Herold, M. (1876); Heymons, R. (1899, *a*); Hirschler, J. (1911; 1912); Hussey, P. B. (1926); Huxley, T. H. (1858); Johnson, C. G. (1937);

Karawajew, W. (1893); Klevenhusen, F. (1927); Kozlowski, A. (1939); Leydig, F. (1848; 1850); Mellanby, H. (1935; 1936); Metschnikoff, E. (1866, *a*, *b*); Morgan, T. H. (1906); Morril, C. V. (1910); Muir, F. A. G. and Kershaw, I. C. (1911; 1912); Paillot, A, (1938); Pedaschenko, D. (1890); Pflugfelder, O. (1937, *a*); Phillips, W. J. (1915); Pierentoni, U. (1909; 1910, *a*, *b*; 1911, *a*, *b*; 1912, *a*, *b*; 1914, *a*, *b*); Poluszynski, G. (1911); Rondelli, M. (1925, *a*, *b*): Schrader, F. (1923); Seidel, F. (1924); Sell, W. (1919); Shinji, G. O. (1919; 1922; 1924); Speyer, W. (1929); Strindbderg, H. (1919. *a*); Tannreuther, G. W. (1907); Teodoro, G. (1920); Tóth. L. (1933; 1935, *a*, *b*; 1937); Uichanko, L. B. (1924); Walczuch, A. (1932); Webster, F. M. and Phillips, W. J. (1912); Wheeler, W. M. (1889, *b*, *c*; 1890, *e*); Will, L. (1883; 1888, *a*, *b*); Witlaczil, E. (1884); Zacharis, O. (1884).

(β) Endopterygota.

15. Neuroptera.

Du Bois, A. M. (1936; 1938); Packard, A. J. (1871, *b*; 1872); Strindberg, H. (1915, *d*); Tichomirowa, O. O. (1890, *a*, *b*; 1892).

16. Mecoptera.

No references.

17. Trichoptera.

Graber, V. (1888, *a*); Marshall, W. S. (1907, *b*); Melnikow, N. (1869); Patten, W. (1884); Zaddach, G. (1854).

18. Lepidoptera.

Acqua, C. (1932, *a*, *b*); Bataillon, E. and Tchou-Su. (1928; 1931; 1933); Beer, S. (1932); Bobretzky, N. (1878, *a*, *b*); Christensen, P. J. H. (1937); Della Pieta, S. (1935); Drummond, M. (1936); Eastham, L. E. S. (1927; 1930, *b*); Foa, A. (1919, *a*, *b*); Friedmann, N. (1934); Ganin, M. (1869, *a*); Graber, V. (1888, *a*; 1890; 1891, *a*); Grandori, R. (1913; 1915, *a*, *b*; 1916; 1919, *a*, *b*; 1920; 1924 *a*, *b*; 1925, *a*, *b*; 1929, *a*, *b*, *c*; 1930; 1932, *a*, *b*); Hatschek, B. (1877); Henking, H. (1890); Henson, H. (1932); Hirschler, J. (1906; 1907, *a*, *b*); Huie, L. H. (1918); Ishiwata, S. (1913); Johannsen, O. A. (1929); Kowalewsky, A. (1871); Lautenschlager, F. (1932); Malpighi, M. (1669); Mariani, G. (1937); Maschlanka, H. (1938); Müller, K. (1938); Niceta, F. (1930); Nusbaum, J. (1884); Paillot, A. (1938); Planter, G. (1888); Rizzi, M. (1912); Saito, S. (1934; 1937); Schwangart, F. (1904; 1905; 1906); Schwartze, F. (1899); Sehl, A. (1931); Seiler, J. (1924); Selvatico, D. S. (1877; 1881; 1882); Strindberg H. (1915, *b*); Suckow, F. W. L. (1818); Tichomiroff, A. (1879;

1882; 1887; 1891); Tirelli, M. (1926; 1928; 1929; 1930; 1931, *a*, *b*; 1934, *a*, *b*; 1935); Tonon, A. (1925; 1927, *a*, *b*); Toyama, K. (1902); Tutt, J. W. (1894); Umeya, Y. (1937); Vaney, C. and Conte, A. (1909; 1910); Verson, E. (1890; 1898; 1909); Wiesmann, R. (1935); Wong, W.-S. and Li, H.-H. (1934); Woodworth, C. W. (1889).

19. Coleoptera.

Blunck, H. (1914); (2) Brauer, A. (1925, *a*, *b*); Brauer, A. and Taylor, A. C. (1936); Bushnell, R. J. (1936); Butt, F. M. (1936); Carrière, J. (1891); Cody, F. P. and Gray, I. E. (1938); Czerski, S. (1904); Deegener, P. (1900); Emden, F. Van. (1925); Ewest, A. (1937); Friederichs, K. (1906); Fulinski, B. (1910; 1911); Graber, V. (1888, *a*, *b*; 1890, *a*, *b*; 1891, *a*, *b*, *d*, *e*);Hallez, P. (1886); Hegner, R. W. (1908; 1909, *a*, *b*; 1910; 1911, *a*, *b*, *c*); Heider, K. (1885; 1889; 1890); Hess, W. N. (1921); Hirschler, J. (1907, *c*; 1908; 1909, *a*, *b*); Hodson, A. C. (1934); Inkmann, F. (1933); Joly, M. (1844); Koch, A. (1931, *a*, *b*; 1936, *a*, *b*); Kölliker, A. (1842); Korschelt, E. (1912; 1924); Kowalewsky, A. (1871); Lécaillon, A. (1897, *a*, *b*; 1898, *a*, *b*); Longchamps, M. de S. (1904); Mansour K, (1927; 1934; 1936; 1938); Megusar, F. (1906); Melnikow, N. (1869); Metschnikoff, E. (1866, *b*); Nusbaum, J. (1889, *a*, *b*; 1890, *b*);Packard, A. S. (1872); Paterson, N. F. (1931; 1932; 1935); Patten, W. (1888); Petrunkewitsch, A. (1898); Pierantoni, U. (1927; 1929; 1930); Provasoli, L. (1932); Reith, F. (1935); Saling, T. (1907); Scheinert, W. (1933); Smreczynski, S. (1931; 1932; 1934); Tichomiroff, A. (1890, *a*, *b*); Tiegs, O. W. and Murray, F. V. (1938); Voeltzkow, A. (1889, *b*); Vogel, R. (1913); Wheeler, W. M. (1889, *a*); Wiemann, H. L. (1910, *a*; 1911); Williams, F. X. (1916); Wray, D. L. (1937).

20. Strepsiptera.

Brues, C. T. (1903); Hoffmann, R. W. (1913; 1914); Noskiewicz, N. and Poluszynski, G. (1924; 1928; 1935).

21. Hymenoptera.

Ayers, H. (1884); Bledowski, R. and Krainska, M. K. (1926); Blochmann, F. (1884; 1886; 1889); Bütschli, O. (1870); Butt, F. M. (1934, *a*) ; Carrière, J. (1890, *a*, *b*); Carrière, J. and Bürger, O. (1897); Daniel, D. M. (1932); Dickel, O. (1902; 1904); Doncaster, L. (1905); Ganin, M. (1869, *a*); Gatenby, J. B. (1917; 1918, *a*, *b*; 1920); Giard, A. (1898); Graber, V. (1888, *a*; 1890); Grandori, R. (1911); Grassi, B. (1884, *a*; 1886); Hecht, O. (1924); Hegner, R. W. (1914, *c*; 1915); Henneguy, L. F. (1891; 1892);

Hill, C. C. (1922; 1923; 1926); Howard, L. O. (1937); Jackson, D. J. (1928; 1935); Kowalewsky, A. (1871); Kulagnin, M. N. (1890, *a*, *b*; 1892, *a*, *b*; 1897); Leiby, R. W. (1922; 1926; 1928); Leiby, R. W. and Hill, C. C. (1923; 1924); Kowalewsky, A. (1871); Lilienstern, M. (1933); Marchal, P. (1897, *a*, *b*; 1898, *a*, *b*, *c*; 1899; 1903; 1904, *a*, *b*, *c*; 1906; 1912); Marshall, W. S. (1907, *a*); Marshall, W. S. and Dernehl, P. H. (1905); Martin, F. (1914); Metschnikoff, E. (1866, *b*); Nelson, J. A. (1911; 1912; 1914; 1915; 1918); Packard, A. S. (1872); Paillot, A, (1937); Parker, H. L. (1931); Patten, W. (1887); Patterson, J. T. (1919; 1921); Petrunkewitsch, A. (1901; 1902); Provasoli, L. (1932); Reith, F. (1931, *a*; 1932); Schleip, W. (1908); Schnetter, M. (1934, *a*, *b*); Silvestri, F. (1906; 1908, *a*, *b*, *c*, *d*; 1910; 1914; 1915; 1916; 1921); Speicher, B. R. (1936); Strindberg, H. (1913, *a*; 1914, *a*; 1915, *a*, *e*; 1916, *a*; 1917, *b*; 1919, *b*); Tanquary, M. C. (1913); Weismann, A. (1882).

22. Diptera.

Auten, M. (1934); Baer, K. E. Von. (1863; 1866); Balbiani, E. G. (1885); Blochmann, F. (1887, *b*); Brauer, F. (1854); Butschli, O. (1888); Butt, F. M. (1934, *a*, *b*); Child, G. P. and Howland, R. B. (1933); Craven, W. N. (1909); Du Bois, A. M. (1932; 1933, *a*, *b*); Escherich, K. (1900, *a*, *b*; 1902, *b*); Felt, E. P. (1911, *a*, *b*); Gabritschevsky, E. (1928); Gambrell, F. L. (1933), Geigy, R. (1931); Graber, V. (1888, *a*; 1889, *b*; 1891, *a*); Grimm, O. (1870, *b*); Hasper, M. (1911); Hegner, R. W. (1912); Henking, H. (1888, *b*); Hinman, E. H. (1932); Holmgren, N. (1904); Howland, R. B. and Child, G. P. (1933; 1935); Howland, R. B. and Sonnenblick, B. P. (1936); Huettner, A. F. (1923; 1935); Jaworowski, A. (1879; 1882); Kahle, W. (1908); Kölliker, A. (1842); Kowalewsky, A. (1886); Kupffer, C. (1866; 1867); Lassmann, G. W. P. (1936); Leuckart, R. (1858; 1865); Lowne, B. (1895); Melnikow, N. (1869); Metschnikoff, E. (1865; 1866, *b*); Miall, L. C. and Hammond, A. R. (1900); Noack, W. (1901); Parks, H B. (1935; 1936); Pauli, M. E. (1927); Poulsen, D. F. (1937 *a*, *b*); Pratt, H. S. (1900); Rabinowitz, M. (1937); Reith, F. (1925); Ritter, R. (1890); Sachtleben, H. (1918); Schaefer, P. E. (1938); Schmidt, F. (1889); Schmuck, M. L. and Metz, C. W. (1932); Strasburger, E. H. (1934; 1935); Strasburger, E. H. and Korner, L. (1939); Voeltzkow, A. (1888; 1889, *a*); Weismann, A. (1863; 1864, *b*; 1882); Wheeler, W. M. (1891, *a*).

23. Aphaniptera.

Balbiani, E. G. (1875); Leeuwenhoek, A. Van. (1695); Packard, A. S. (1872); Strindberg, H. (1917, *a*); Weismann, A. (1863).

(*b*) *General.*

Agassiz, L. (1851); Baer, K. E. Von. (1828); Balbiani, E. G. (1882; 1885); Balfour, F. M. (1880); Berlese, A. (1898; 1899; 1909; 1913); Blochmann, F. (1887, *b*, *c*); Bobretzky, N. (1878); Brandt, A. (1876; 1880, *a*, *b*); Braem, F. (1895); Bruce, A. T. (1887); Buchner, P. (1930); Bugnion, E. (1921); Burmeister, H. (1836); Carrière, J. (1891); Cholodkowsky, N. (1889; 1891, *b*, *c*); Dawydoff, C. (1928); Deegener, P. (1914); Depdolla, P. (1928); Dohrn, A. (1866; 1876); Eastham, L.E.S. (1930, *a*); Emery. (1889); Escherich, K. (1900, *c*; 1901; 1902, *a*); Faussek, V. (1911); Gadzikiewicz, W. (1905); Ganin, M. (1869, *b*; 1874, *a*, *b*); Goodrich, E. S. (1895; 1897); Graber, V· (1877–1879; 1878; 1879; 1888, *a*, *b*, *c*; 1889, *a*, *b*, *c*; 1890, *a*; 1891, *a*, *b*, *c*, *e*, *f*); Grassi, B. (1889); Haase, E. (1889, *a*, *b*); Haeckel, E. (1874; 1877); Hallez, P. (1886; 1887); Hegner, R. W. (1911, *c*; 1914, *a*, *b*; 1917); Heider, K. (1897; 1928); Henking, H. (1888, *a*; 1891, *b*; 1892); Henneguy, L. F. (1904); Henrikson, K. (1928); Hertwig, O. (1906); Hertwig, O. and Hertwig R. (1881); Hertwig, R. (1881); Heymons, R. (1893, *b*; 1894, *a*, *b*; 1895, *b* ; 1896 *b*, *d*; 1897, *d*, *f*; 1898, *b*; 1899, *b*; 1905); Heys, F. (1931); Hirschler, J. (1924; 1939); Hussey P. B. (1926); Imms, A. D. (1934; 1937); Jackson, D. J. (1935); Jaworowski, A. (1882; 1891; 1897); Joly, N. (1844); Kellog, V. L. (1902); Kessler, Fr. H. (1879); Kölliker, A. (1842); Korotneff, A. (1894); Korschelt, E. (1936); Korschelt, E. and Heider, K. (1892; 1910); Kowalewsky, A. (1871); Lang, A. (1891; 1903); Leeuwenhoek, A. Van. (1695); Leiby, R. W. (1928); Lubbock, J. (1859); Macbride, E. W. (1914); Mayer, P. (1876); Melnikow, N. (1869); Metschnikoff, E. (1866, *b*); Needham, J. (1931; 1934); Nusbaum, J. (1889, *b*; 1890, *a*); Packard, A. S. (1872; 1875); Pander, H. C. (1817); Patten, W. (1887; 1890); Patterson, J. T. (1927); Petrunkewitsch, A. (1933); Rabl, C. (1889); Redi, F. (1688); Richards, A. G. (1932); Robin, C. (1862, *a*, *b*); Roonwal, M. L. (1939, *a*, *b*); Ryder, J. A. (1886, *a*); Sammogia, A. (1932); Schimkewitsch, W. (1885); Schneider, A. (1883, *a*, *b*; 1885, *a*, *b*); Silvestri, F. (1937); Smith, J. B. (1896); Snodgrass, R. E. (1925; 1928; 1935; 1938); Swammerdam, J. (1737); Tichomiroff, A. (1892); Wagner, J. (1894); Weber, H. (1937, *a*, *b*; 1938); Weismann, A. (1864, *a*; 1882); Wheeler, W. M. (1890, *b*; 1891, *b*, *c*; 1892, *a*, *b*); Wielowiejski, H. R. (1886); Willey, A. (1899); Wolff, C. F. (1759); Zaddach, G. (1867); Zograf, N. [Sograff, N.] (1892).

(*c*) *Experimental Embryology.*

Geigy, R. (1931); Hegner, R. W. (1908; 1909, *a*, *b*; 1910; 1911, *a*, *b*, *c*); Howland, R. B. and Child, G. P. (1935); Howland, R. B. and Sonnenblick, B. P. (1936); Huxley, J. S. and De Beer,

G. R. (1934); Krause, G. (1934); Maschlanka, H. (1938); Megusar, F. (1906); Morgan, T. H. (1927); Oka, H. (1934); Pauli, M. E. (1927); Reith, F. (1925, 1931, *a*, *b*, *c*; 1932; 1935); Richards, A. G. and Miller, A. (1937); Schnetter, M. (1934, *a*, *b*); Seidel, F. (1926; 1928; 1929, *a*, *b*; 1931; 1932; 1934; 1935; 1936); Thompson, V. (1934).

(d) Bacterial Symbiosis.

Blochmann, F. (1887, *a*; 1892); Breest, F. (1914); Grandori, R. (1924, *a*; 1929, *a*); Hecht, O. (1924); Hinman, E. H. (1932); Klevenhusen, F. (1927); Koch, A. (1931, *a*, *b*; 1936, *a*, *b*); Lilienstern, M. (1933); Peirentoni, U. (1909; 1910, *a*, *b*; 1911, *a*, *b*; 1912, *a*; 1914, *c*; 1920; 1923; 1924; 1927; 1929; 1930); Ries, E. (1931); Rondelli, M. (1925, *a*, *b*); Scheinert, W. (1933); Tóth, L. (1937); Walczuch, A. (1932).

(e) Other Arthropods, etc.

(1) Brauer, A. (1894; 1895); Cholodkowsky, N. (1895); Faussek, V. (1911); Glen, E. H. (1919); Goodrich E. S. (1895; 1897); Grassi, B. (1884, *b*); Heymons, R. (1897, *e*; 1898, *a*; 1901); Kennel, J. (1885; 1888); Kishinouye, K. (1894); Manton, S. M. (1928; 1934); Metschnikoff, E. (1874; 1875); Nair, B. (1939); Pflugfelder, O. (1932); Roonwal, M. L. (1939, *a*); Sclater, W. L. (1888); Sedgwick, A. (1885; 1886; 1887; 1888); Sheldon, L. (1889); Silvestri, F. (1932); Sollaud, E. (1933); Suckow, F. W. L. (1818); Tiegs, O. W. (1939); Willey, A. (1898); Zograf, N. [Sograff, N.] (1882; 1883).

VI. APPENDIX.

While this work was in the press, three noteworthy papers have appeared which deserve mention. Firstly, H. R. HAGAN (*Ann. Entom. Soc. Amer.*, vol. XXXII, pp. 264-266, 1939) describes in a viviparous cockroach of the Hawaiian Islands, *Diploptera dytiscoides*, remarkably long and tubular pleuropodia which presumably convey nutriment from the maternal genital cavity to the embryo through the micropylar aperture in the egg-wall. Secondly, in an advance abstract of his dissertation on the embryology of *Pteronarcys proteus* (Plecoptera), kindly sent by Dr. A. MILLER (for Part I, already published, see p. 83), it is shown that the *labral*, antennary, intercalary, mandibular, maxillary and labial pairs of coelom sacs are developed in the head, the labral pair being of special interest. Lastly. E. L. KESSEL (*Smithsonian Misc. Coll.*, vol. XCVIII, No. 3, 1939) gives us the first comprehensive account of the embryology of some fleas (Aphaniptera).